# STUDENTS' AID IN OPHTHALMOLOGY

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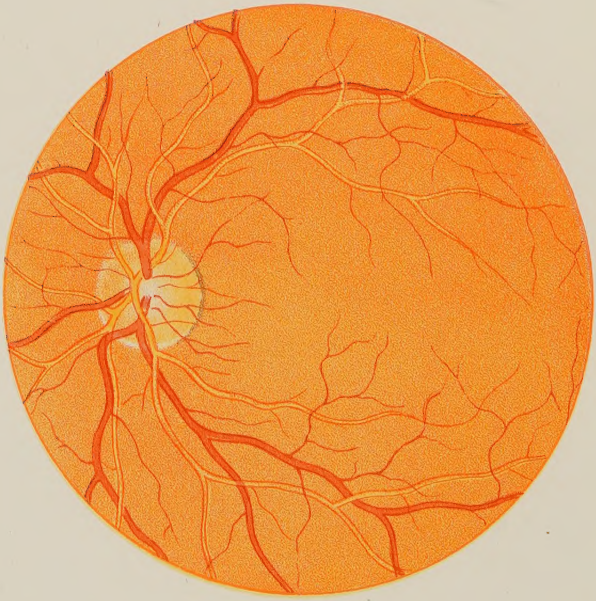

NORMAL FUNDUS.

# STUDENTS' AID

IN

# OPHTHALMOLOGY

BY

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# PREFACE.

Students entering upon a course of study of Ophthalmology are confronted by many technicalities, and for this reason are often unable to profit by their observation of clinical cases. This book is intended for study preliminary to a course of clinical lectures upon the eye, or for reference during attendance upon such a course. Its preparation was suggested by experience in teaching and by observation of the difficulties felt by students of this branch of medicine. It is hoped that the book may prove useful to practitioners who desire to obtain sufficient knowledge of the specialty to enable them to diagnosticate and treat cases of ocular disease.

I wish to make grateful acknowledgment to Dr. Amy S. Barton and to Dr. Edward Jackson for their interest and help.

While most of the figures were drawn expressly for this book, my thanks are due to Bonschur & Holmes, to Charles Lentz & Sons, and to the Fox Optical Co. for illustrations of instruments, and to the latter firm for test cards from which reproductions were made.

GERTRUDE A. WALKER.

*125 So. 16th St., Philadelphia,*
*October, 1895.*

# TABLE OF CONTENTS.

*"It is the mission of books that they help one to remember."*

# STUDENTS' AID

IN

# OPHTHALMOLOGY.

## CHAPTER I.

### METHOD OF EXAMINING THE EYES.

The data of a case should be arranged methodically and recorded accurately. Carefully taken notes assist the surgeon in making his diagnosis, and influence him in his determination of treatment; they may also prove useful for future reference.

Students of medicine are often at a loss as to how to conduct a detailed examination of a patient. Even experienced physicians are not always free from a tendency to ask unnecessary questions or to omit necessary ones. Some begin an investigation at the point where it should end, or attempt to elicit the more remote symptoms before having noted the more apparent ones.

In examination of the eye, method is especially to be recommended, for very often the organ is quite normal in appearance, and defects are brought out only by questions and by tests which have particular significancies. As an introduction to the study of ophthalmology, the following scheme is given, together with a brief explanation of each division and subdivision.

**I. Family Predisposition to Eye Trouble.**

Many of the most serious diseases of the eye are the result of hereditary influences, and refractive errors also are often found to have repeated themselves in family histories.

**II. Previous Attacks of Similar Trouble.**

A note in this regard gives one a suggestion as to whether the patient's condition is acute or chronic, or an acute attack engrafted upon a chronic disease.

**III. Date of Beginning of Present Complaint.**

The stage of the disease can be ascertained by means of this note, and the prognosis may be modified by it.

**IV. Subjective Symptoms.**

It is best at this point to encourage the patient to give a short account of his reason for seeking advice. The surgeon can, however, so direct this personal account as to draw out a description of the following symptoms :—

1. *Pain.*
   - (*a*) Situation.
   - (*b*) Character.
   - (*c*) Duration.

Severe pain in the eyes themselves is usually associated with grave lesions. Headache may or may not be due to eye strain. Frontal and temporal headache is the type usually met with in eyes whose refractive power is defective. Occipital headache may occur as a symptom of asthenopia, but is not so frequent as the frontal. The headache is invariably induced or aggravated by close work and by artificial light. It is usually dull and persistent.

2. *Increased lacrymation.*
   - (*a*) Constant.
   - (*b*) Upon close application.

Increased lacrymation which is continual should lead one to make a careful inspection of the lacrymal apparatus.

Tendency of the eyes to water only when the patient applies himself to close work points to a probable error of refraction. It is one of the results of hyperemia of the conjunctiva induced by eye strain.

3. *Burning, itching, sense of foreign body in the eye.*

These symptoms are grouped together because they are seldom disassociated in the patient's experience. Their mention should always lead the surgeon (if he has not already received a similar hint from a complaint of pain in the eye) to search for a foreign body. If an offending substance does not lodge upon the cornea, it is very often discovered on the under surface of the upper lid. Should no foreign body be detected, one may ascribe the symptoms to irritation of the conjunctival sac from some other cause.

Flakes of mucus floating over the cornea will often greatly annoy the patient, both because of the irritation they produce and the temporary obscuration of vision.

4. *Vision.*

(*a*) Dimness, gradual or sudden; constant or occasional.

(*b*) Floating bodies. Colors.

Gradual failure of vision may imply developing cataract, increasing myopia, or a serious disturbance in the media or in the coats of the eye. Sudden loss of vision suggests detachment of the retina, or some equally grave lesion. One should not rely too implicitly, however, upon the patient's statement, for the first discovery of congenital blindness in one eye is frequently mistaken for sudden loss of vision. Constant dimness of vision leads one to suspect an error of refraction or some disease of the eye. Occasional blurring may be a symptom of eye strain, or may be due to mucus swept over the cornea by movements of the lids.

Floating bodies in the vitreous are annoying but harmless. They are the indication of former inflammatory trouble in one or more coats of the eye. They may disappear spontaneously, or may continue throughout life. Relief can not be promised, but fear as to their tendency to injure the eye may be allayed.

In the prodromal stage of glaucoma the patient complains of seeing rings of colors about a light; on the other hand, children frequently complain of a similar disturbance of vision. In the latter case the symptoms seem to depend on error of refraction.

**V. Record of Visual Power.**

1. *For Distance.*
2. *For Near.*

The record for distance shows the power of the eye for focusing parallel rays. The record for near is the result of a test of the accommodative power of the eye, and it should be observed in connection with the age of the patient. If the patient is wearing glasses, they should be neutralized and the result recorded, together with the visual power obtained by their use.

**VI. Objective Symptoms.**

So far, it may be observed, the eyes of the patient have not been touched by the surgeon, nor have any tests been employed, except those associated with the record of visual power. Had the lids been touched, the lacrymal apparatus examined, and the general aspect of the anterior part of the eye studied, greater hyperemia would have been induced, and the record of visual power would have been inaccurate because of the suffusion of the eyes by lacrymal fluid.

The objective symptoms are learned by close inspection and by manipulation. Examination should proceed from without inwards.

1. *Lids.*
2. *Conjunctiva.*
3. *Lacrymal apparatus.*
4. *Cornea.*
5. *Iris.*
   (*a*) Shape, size, and color.
   (*b*) Contractile power.
6. *Anterior chamber.*
7. *Tension.*
8. *Muscular balance.*

Thickening of the margins of the lids, scattered or misplaced lashes, any focus of inflammation (as hordeolum), and the presence of tumors should be noted. In marginal blepharitis crusts are seen at the bases of the lashes.

The normal palpebral conjunctiva (*i. e.*, that part of the conjunctival sac which lines the lids) is transparent, and allows a view of the regularly arranged Meibomian glands. In inflammation of the conjunctiva these glands can not be seen clearly. The variety of the inflammation can be diagnosticated by noting the appearance of the conjunctiva. The ocular conjunctiva may present various phenomena. Congestion of the vessels should be noted, and particularly the pericorneal zone, if it exists. Chemosis and ecchymoses are always striking in appearance, and should be accurately described. Wounds or lesions of any kind should not be overlooked. The character of the discharge from the conjunctival sac is always significant.

The cornea should next be studied, any opacities or irregularities of its surface noted and described, and its transparency and luster examined. This can best be done by oblique illumination. The "arcus senilis" observed in the old is the result of a physiological deposit of colloid material near the corneal margin. There is always a rim of

clear corneal tissue between the arcus senilis and the margin of the cornea. The arcus may be partial or complete.

The iris is so shaped that normally its pupillary opening occurs a little to its nasal side. Any irregularities in the shape of the pupil must be due to fault in the iris. Anterior or posterior synechiæ (*i. e.*, adhesions of the iris to the cornea or to the lens) can be discovered by oblique illumination. Irregularity of the pupil may point to nervous disease. The color of the one iris should be compared with that of the other. One soon learns to recognize the muddy, greenish color of an inflamed iris. It is best seen in the blue or in the gray iris, and is less appreciable in the brown one. The size of the pupillary opening varies in different individuals according to disposition, state of health, and state of mind. An unusually dilated pupil or an unusually contracted one may prove a very important symptom. The pupil in glaucoma, for instance, is always dilated; in iritis it is contracted. The contractile power of the iris should be studied, both for distance and near, and for light. The direct, or independent, action of each iris should first be examined, afterwards "consensual reaction" should be studied. A tremulous iris is one which has lost the normal support of the zonula of Zinn, and it indicates either absorption or dislocation of the lens. The pupillary reflex often gives one a hint as to the nature of the disease one is about to deal with. The mature opaque cataract, for instance, is easily recognized.

A note as to the depth of the anterior chamber is of importance, particularly when the case is one for cataract extraction or for iridectomy.

The tension of each eye should be determined in every case. The patient should be told to look down, while the surgeon palpates the eyeball in much the same manner as

he would palpate an abscess. Slight departure from the normal tension is not easily appreciated by touch, but decided rigidity or softness of the globe is quickly recognized by this test.

To test muscular balance, require the patient to look at some distant object, and then, while both eyes are fixed upon this object, place before one eye a card or an opaque disk and watch what movement, if any, takes place on the part of the covered eye. Test each eye separately, and note any inward or outward deviation that may occur on uncovering. Repeat the test for some near point. This is known as the "cover test" and has the advantage of combining simplicity with a reasonable amount of reliability. Limitation of movement, either partial or complete, can be recognized by requiring the patient to allow his eyes to follow the tip of a pencil or the surgeon's finger as it is moved first to one side and then to the other, then above and then below.

**VII. Ophthalmoscopic Examination.**

Having now obtained all the data possible from a study of the anterior segment of the eye, the ophthalmoscopic examination completes the preliminary record.

1. *The Media.*—The condition of the media is best seen by looking into the eye with the ophthalmoscope from a distance of about twelve inches, employing sometimes to advantage a plus lens.

2. *The Disk.*—(*a*) Shape, size, color. (*b*) Its vessels. The disk (nerve-head, papilla) should be first studied in regard to its shape, size, and color, then in regard to the size and arrangement of the vessels which spring from its center. Cupping of the disk should always be noted, even when of the physiological variety.

3. *The Eye-ground in General.*—The region around the

disk should be described, and also the general appearance of the eye-ground.

4. *The Macular Region.*—The macula can be best brought into view when the patient is told to look into the ophthalmoscopic mirror. The fovea is seen as a bright spot. Few vessels are seen in this vicinity. Abnormal conditions in the region of the macula are peculiarly significant.

5. *Refraction at the Macula.*—One should try to estimate the amount of refractive error at the macula more than at any other part of the fundus. It is done by selecting a vessel running in a certain direction and noting what glass in the wheel of the ophthalmoscope best brings this vessel into view. Then a vessel at right angles to the first one chosen should be found, and its refraction determined. The ophthalmoscope, however, is an instrument not accurately adapted for estimation of refractive error. It is more particularly a means for studying the details of the fundus.

Examination of the eye by use of what is known as "the indirect method" is described in the fifth chapter. Questions in reference to general health are often necessary in order to discover the cause of disturbance in the eye.

For convenience in reference, the following summary is given :—

I. Family predisposition to eye trouble.
II. Previous attacks of similar trouble.
III. Date of beginning of present complaint.
IV. Subjective symptoms.
    1. Pain.
        (*a*) Situation.
        (*b*) Character.
        (*c*) Duration.
    2. Increased lacrymation.
        (*a*) Constant.
        (*b*) Upon close application.

3. Burning, itching, sense of foreign body in the eye.
4. Vision.
    (*a*) Dimness, gradual or sudden; constant or occasional.
    (*b*) Floating bodies. Colors.

V. Record of visual power.
1. For distance.
2. For near.

VI. Objective symptoms.
1. Lids.
2. Conjunctiva.
3. Lacrymal apparatus.
4. Cornea.
5. Iris.
    (*a*) Shape, size, and color.
    (*b*) Contractile power.
6. Anterior chamber.
7. Tension.
8. Muscular balance.

VII. Ophthalmoscopic examination.
1. The media.
2. The disk.
    (*a*) Shape, size, color.
    (*b*) Its vessels.
3. The eye-ground in general.
4. The macular region.
5. Refraction at the macula.

## CHAPTER II.

### LENSES.

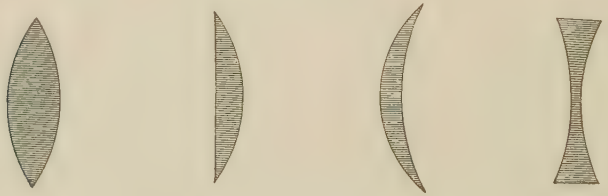
A refracting medium is any substance through which rays pass and by which they are turned from their original courses. Rays coming from an infinite distance are parallel. All rays in nature are, however, more or less divergent. In ophthalmology, a distance of twenty feet, or six meters, is considered equal to an infinite distance, although in reality it is finite. Rays proceeding from an object situated at or beyond six meters are so slightly divergent as to make but small difference in practical calculations.

In the normal eye, parallel rays are brought to a focus upon the retina without any effort of accommodation.

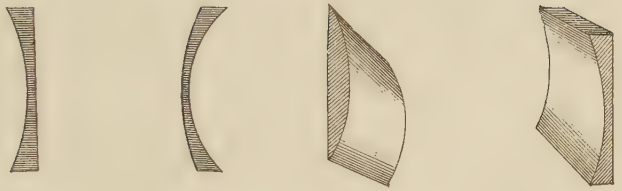
There are four refracting media in the eye: the cornea, the aqueous humor, the lens, and the vitreous humor.

A lens is a transparent refracting medium bounded by curved surfaces, or by a curved surface and a plane.

The varieties of lenses used in ophthalmology are the following:—



1. The double convex. 2. The plano-convex. 3. The converging meniscus. 4. The double concave.



5. The plano-concave. 6. The diverging meniscus. 7. The convex cylinder. 8. The concave cylinder.

Convex lenses *converge* rays. The point at which parallel rays are caused by the lens to come to a focus is known as the "principal focus" of the lens. The distance from the principal focus to the optical center of the lens is called the "focal distance" of the lens.

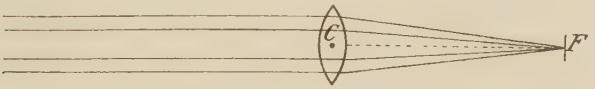



Fig. 1.—F. Principal focus. C. Optical center. CF. Focal distance.

Lenses are numbered in accordance with their focal distances. A convex lens always has its principal focus on the opposite side from that upon which the rays impinge.

The images formed by convex lenses are real (*i. e.*,

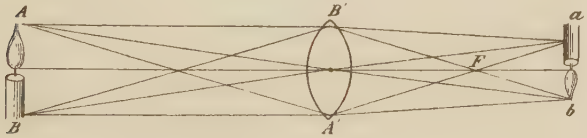



Fig. 2.

actual) or virtual, according to the relative position of the object from which the rays proceed and of the lens which receives and refracts these rays.

In the above figure, A B is placed at a point *beyond* the

focal distance of the lens. Parallel rays proceeding from A and B intersect, after refraction, at the point F, which is, then, the principal focus of the lens. All the rays which pass through the optical center of the lens are practically unrefracted. The rays BB′ and AA′ pass on, after refraction by the lens, to meet the other rays and to take part in the formation, just beyond the principal focus of the lens, of a small inverted image (a b) of the object AB.

In Fig. 3, the object A B is placed at a point *within the principal focus* of a convex lens. Divergent rays from the points A and B are refracted by the lens and enter the eye. These rays are perceived as if they had proceeded from

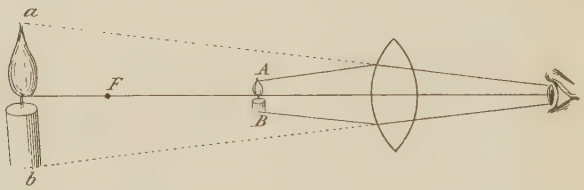



Fig. 3.

the enlarged and virtual image a b. This is the principle of magnification.

Since the convex lens possesses the power to form *real* images, it is called the positive lens and is designated by the sign +.

The images formed by concave lenses are always virtual, since such lenses cause rays to diverge rather than to converge. The focus of a concave lens is on the same side of the lens as that of the object from which the rays proceed, and because this focus is determined by a projection backwards of the refracted rays it is called "negative" or "virtual."

In Fig. 4, A B is an object placed before a concave lens.

Rays from this object are rendered divergent by passage through the lens. The only image formed by the lens is a negative (or virtual) one, and it depends upon a projection backwards of the divergent rays to a point on the same side as the original object. At the point where the projected rays intersect one another is formed a virtual, erect, and diminished image of the object A B.

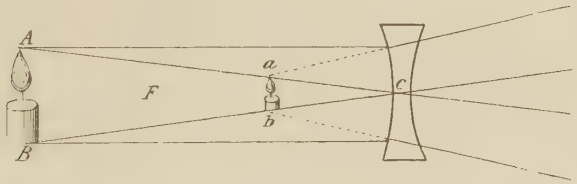



FIG. 4.

Since, therefore, the concave lens can produce only virtual images, it is known as a *negative* lens and is designated by the sign —.

*The strength of a lens varies inversely as the length of its radius of curvature.*

The lens, for example, whose radius of curvature is eight centimeters in length, has a strength double that of a lens whose radius is sixteen centimeters long.

*A medium whose surfaces are parallel to each other (even if they be curved surfaces) has no practical effect upon rays which pass through it.*

The truth of this latter law is illustrated by common window glass, whose shape may be either plane or curved, so long as the radius of curvature of the one surface is everywhere proportionate to that of the other surface. Upon these principles depends the estimation of strength (*i. e.*, refractive power) of all lenses. The "converging meniscus" is a lens whose one surface is convex while the

other is concave, but whose convex (or converging) surface has a shorter radius of curvature than that of its concave surface. Similarly, the "diverging meniscus" has two surfaces opposed in refractive power to each other, but its diverging increment is more powerful than the converging one. Lenses may be ground in various forms, in accordance with the special effect desired.*

*The Cylindrical Lens.*—This form of lens is a segment of a cylinder. Examination of any cylinder (as, for instance, an ordinary bottle) will reveal the fact that there is curvature in but one direction, viz.: from side to side. Up and down (*i. e.*, in the axis of the cylinder) there is no curvature. Rays passing through the cylinder are not refracted *in the direction of its axis*, since in this direction the two surfaces are parallel. The strength of the cylinder is fixed by the curvature possessed by the surface *at right angles to the axis.*

*The Prism* is a transparent refracting medium having two surfaces inclined to each other. The point of intersection of these two surfaces is the "apex" of the prism. The broadest part of the prism is its "base." The number engraved on each prism represents the number of degrees of the apical angle. The angle of deviation (which represents more accurately the work done by the prism) is about one-half that of the angle at the apex.

If a lens has a focal distance of *one meter* it is said to have a strength of *one diopter.* The meter, in other words, denominates focal distance, the diopter denominates refractive power. *The strength of a lens varies inversely as its focal distance.* For example : if a lens of one diopter's strength

* For detailed description of this part of the subject see "Spectacles and Eyeglasses," by Dr. R. J. Phillips. Published by P. Blakiston, Son & Co , Philadelphia.

has a focal distance of one meter, a stronger lens, say one of two diopters, must have a shorter focal distance by one-half that of a one-diopter lens. Similarly, a lens of less strength than one diopter (one-fourth of a diopter, for instance, written 0.25) has a longer focal distance by four times that of a one-diopter lens, or four meters.

The metric system of numbering lenses is the one now in common use. Its unit is a lens of one meter's focal distance. Up to the year 1872 the so-called "inch-system" prevailed. The unit of the inch-system was a lens whose focal distance equaled one inch. This was an extremely strong lens. All weaker lenses were perforce designated in terms of fractions. Apart from the inconvenience of working in fractions, the denomination "inch" had different significations in different countries, the French inch, for example, varying from the English inch. Occasionally, however, one is called upon to deal in terms of the old system, and it is best to understand how to convert the one into the other. A method which is convenient, if slightly inaccurate, is based upon the assumption that a meter equals forty inches. A single example will serve better than a rule :—

A five-inch lens is one which focuses at five inches. Five inches equals one-eighth of a meter (or 40 inches). The lens whose focal distance is one-eighth of a meter is, in metrical terms, an 8D lens.

**Varieties of Lenses used to Correct Focal Errors.**

1. *The simple sphere.*

This is a form of lens, either convex or concave, which affects all impinging rays in one and the same manner. It corrects the uncomplicated forms of error of refraction.

2. *The simple cylinder.*

This form of lens, since its refractive power is limited to the direction of its curvature, is used to correct an error

which exists in but one meridian of the eye, the other meridian being normal, or "emmetropic."

3. *The sphero-cylinder.*

This form of lens is a combination of a sphere with a cylinder, and is used to correct that variety of error in which the refraction of one principal meridian of the eye is not the same (it may be in amount or it may be in kind) as that of the other principal meridian.

4. *The crossed cylinder.*

This is a form of lens made up of two cylinders with their axes at right angles to each other. It is seldom employed, except as an aid in trial for glasses.

## CHAPTER III.

### ERRORS OF REFRACTION.

**I. Hypermetropia.**

This error of refraction depends upon that disproportion between the power of the refracting media and the position of the retina which, when the eye is at rest, causes parallel rays to reach the retina before they have been brought to a focus.

If it were possible to continue the rays in their courses,

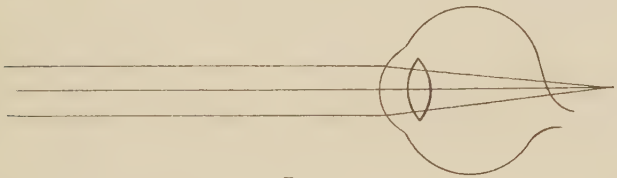


FIG. 5.

they would be found to focus at some point more or less distant (according to the amount of error) behind the eye. The hypermetropic eye is constantly under an effort to so adapt itself for parallel rays as to focus them accurately on the retina. It can do this by means of contraction of the ciliary muscle. This contraction relaxes the tension of the suspensory ligament of the lens, and the lens, being elastic, takes on a more rounded shape and so adds to its own refractive power.

The hypermetropic eye at rest is not adapted for any rays except *converging* ones, and these never occur in nature. The hypermetrope is said, therefore, to be "far-sighted,"

for the more closely rays approach parallelism (or infinity) the more easily can the eye receive them and the clearer will be the image which is formed upon the retina.

The variety of hypermetropia most frequently met with is that due to fault in the antero-posterior diameter of the eye. The hypermetropic eye is, as a rule, short from before backwards, and this is most often a congenital defect. Because of the habit formed in early life of constantly accommodating for both distant and near objects, the hypermetropic patient finds it difficult, and sometimes actually impossible, to relax the tonic spasm in which the ciliary muscle is held.

A convenient division of hypermetropia is made thus :—

1. Latent (involuntary).
2. Facultative (voluntary). } Manifest.
3. Absolute.

*Latent* hypermetropia is that part of the total error which is revealed only by mydriasis. It is corrected at all times by the accommodation.

*Facultative* hypermetropia is that portion of the total error which may be corrected at one time and remain uncorrected at another time.

*Absolute* hypermetropia is that portion which lies beyond the correcting power of accommodation.

Under favorable circumstances the whole of the absolute, together with a part, or, perhaps, the whole of the facultative, may be discovered by trial-lenses. It is then called "manifest," and glasses prescribed without the use of any mydriatic are spoken of as "the manifest correction."

The part known as latent can be estimated only by the use of a mydriatic. Herein lies the reason for putting the

ciliary muscle absolutely at rest when one desires to measure the actual refraction of the eye.

After the total amount of hypermetropia in a patient's eye has been measured, one should prescribe (under ordinary conditions) the glasses which render the eyes emmetropic. But the average patient can not easily give up his old habit of accommodating for all distances, and he will be obliged to pass through what is called "the period of adaptation" before his glasses give him clear distant vision. Convex glasses encourage relaxation of the ciliary muscle, and after a varying length of time (ranging from days to weeks) the eyes consent, as it were, to allow the glasses to do the work formerly assumed by the accommodative mechanism.

When the hypermetropia is high, it is often well to prescribe the glasses with which the patient can get full vision after the effect of the mydriatic has passed away. Such a patient should be told that later he will need to have his glasses changed for stronger ones which will more fully correct his error.

From what has been said it can be seen that in order to accustom the eyes to the use of their correcting glasses, the glasses should be constantly worn. There occur cases, however, in whom the hypermetropia is so slight as to give no inconvenience except in the performance of near work. For such people glasses may be prescribed for near use. Patients such as these are usually between the ages of thirty-five and forty, whose power for accommodation is diminishing, and who cannot afford to give up any of this power for the purpose of correcting hypermetropia.

The *Clinical Symptoms* of hypermetropia may be referred to strain put upon the function of accommodation. Frontal headache, heaviness of the lids, occasional blurring

of print or of stitches, increased lacrymation, and tendency to inflammation of the conjunctiva (with all the discomforts and lesions dependent upon such inflammation) are the most familiar symptoms. They may all be grouped under the expressive term, "accommodative asthenopia."

Hypermetropia dependent on other causes than that of too short axial diameter of the eye is rarely observed. But if any of the media be defective in such a way as to lessen the refractive power of the eye, hypermetropia may exist. The most frequent example is seen in the "aphakic" (or lens-less) eye.

The distant vision in hypermetropia is, as a rule, good, unless the focal error is complicated by astigmatism, or is so great in amount as to be beyond the correcting power of the accommodation.

**II. Myopia.**

This error of refraction depends upon that disproportion between the power of the refracting media and the position

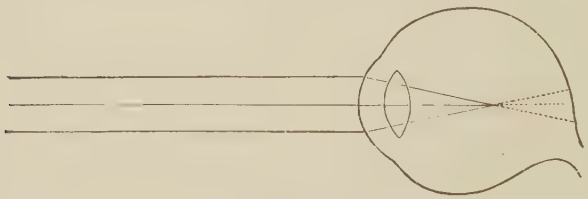


FIG. 6.

of the retina which causes parallel rays to focus before they have reached the retina.

The rays pass on, after intersecting one another at the focus, and form upon the retina blurred images of distant objects.

The myopic eye possesses no mechanism adapted for the correction of this error. Accommodation is here in abey-

ance, and the media cannot be influenced in any way to farther diminish their refractive power. Distant vision, and, up to a certain point, near vision as well, is blurred in all cases of myopia. The point at which the images of objects may be clearly seen varies with the amount of myopia. An object may be so placed before a myopic eye as to emit rays sufficiently divergent to focus clearly and sharply on the retina. For every myopic eye there is such a point. It is called the "punctum remotum," or far point. The amount of myopia present in an eye may be approximately determined by noting this far point of vision and then substituting the denomination of strength for that distance, exactly as in the case of expressing focal distance in terms of the diopter. For example, if a myope reads fine print at a distance of ten centimeters (or one-tenth of a meter) we judge that his myopia equals in amount the strength of the lens whose focus is ten centimeters; in other words, a 10-D lens. One should not be too positive, however, in forming an opinion as to the patient's variety of error from his tendency to hold his work close to the eyes. Some hypermetropes habitually choose large, blurred images in preference to small, distinct ones, and to accomplish this purpose they deliberately widen their visual angle by reading within the usual distance. The myopic eye, then, is adapted only for divergent rays, while the hypermetropic eye is, as has been seen, adapted only for convergent rays.

Myopia, like hypermetropia, is most often dependent upon a fault in the axial diameter of the eye. Rarely it is congenital. Its predisposing causes are usually of constitutional character. A weakened resistance of the coats of the eye is often but a manifestation of weakened resistance of the tissues throughout the body. The necessity for convergence and for accommodation, which is felt on the part

of every child as soon as he begins to apply himself to study, induces hyperemia of the eyes. If the tissues have only a low resistant power, they stretch more or less, and in this way an eye which was emmetropic or even hypermetropic at birth may become myopic.

The presence of myopia has for a long time been associated with the performance of near work, and for that reason it became (with some justice) a badge of intellectuality. Myopia may occur, however, in those who do any kind of fine or close work, as engravers, compositors, and seamstresses. On the other hand, many instances might be quoted of the occurrence of myopia in persons whose occupations have never required close application.

Myopia should be estimated under mydriasis, as in the case of hypermetropia. Otherwise, irregularities in refraction might escape detection. Until quite recently there was a prejudice on the part of ophthalmologists in general against the correction of the whole of the myopia existing in an eye, but it is now believed that full correction tends to prevent the progress of myopia.*

Myopia may be either *stationary* or *progressive*. The stationary type is that in which the error of refraction reaches a limit beyond which it does not tend to proceed. This arrest of progress usually occurs at the time when full growth is attained. The progressive form is the destructive type. The coats of the eye are subjected to gradual stretching, and ultimately one or more of them gives way. Since the weakest part of the globe is at the posterior pole, the first signs of rupture occur there. *Posterior staphyloma* (ocular hernia) ensues. This is seen at the temporal side

* See Jackson: "The Full Correction of Myopia," *Transactions of the American Ophthalmological Society*, Vol. VI.

of the optic nerve-head. Other lesions of progressive myopia are atrophy of the retina and choroid, retinal hemorrhages, detachment of the retina, luxation of the lens (as a result of atrophy of the Zonula of Zinn), followed by amblyopia or by total blindness.

*Clinical Symptoms* of the moderate type of myopia are not markedly different from those of hypermetropia. Because of the strain upon convergence, there may follow evidences of muscular asthenopia, such as headache, weariness of the eyes, and tendency to inflammation of the conjunctiva. The most constant complaint is that of imperfect distant vision.

The long axial diameter is usually a property of the myopic eye as a whole. Occasionally, one sees a form of myopia which occurs in the cornea alone, the relation between the other media and the retina being quite normal. This form is known as "keratoconus," or "conical cornea." It is best recognized by examination with the skiascope, although simple inspection made at one side of the eye may reveal the anomaly.

Myopia from other causes than those associated with too long an axial diameter is rare. Too great refractive power in the lens for any reason may produce an error of refraction which is myopic in effect. This change in the lens sometimes develops in the old, and is due to senile influences. Such patients find they can lay aside the glasses they have always used for reading, and believe they have received "second sight."

**III. Astigmatism.**

This error of refraction is due to lack of uniformity in curvature of the refracting media of the eye. The cornea is most often at fault, although so-called "lenticular astigmatism" is not uncommon.

In speaking of the curvature of the cornea, one differ-

entiates two principal meridians, which in the regular forms of astigmatism are at right angles to each other. One meridian represents the greater degree of curvature, while the other meridian represents the lesser degree.

*Regular Astigmatism* may be defined as difference in curvature of the two principal meridians of the refracting surface. For example, the vertical meridian may be emmetropic, while the horizontal meridian is hypermetropic. Rays passing through such a refracting medium are not collected (as by the spherical lens) at one focal point, but (as by the cylindrical lens) are focused so as to form a line parallel to the ametropic meridian.

*Irregular Astigmatism* is that form of astigmatism in which the unequal curvatures of the cornea bear no constant relation to each other. There are no principal meridians; on the contrary, one portion of the cornea may present a totally different refractive power from that of another portion. This kind of astigmatism is usually the result of cicatrices in the cornea. When found in cases of clear cornea, it may quite safely be assumed to be due to irregularities in the curvature of the lens. Cases occur, however, in which the cornea seems perfectly clear and yet shows irregular astigmatism as a result of disease which has left no other trace.

**The Varieties of Regular Astigmatism.**

1. *Simple hypermetropic.*

In this form one meridian is emmetropic, the other hypermetropic.

2. *Simple myopic.*

In this form one meridian is emmetropic, the other myopic.

3. *Compound hypermetropic.*

Here one meridian is hypermetropic to a certain extent, the other hypermetropic to a greater extent.

4. *Compound myopic.*

Here one meridian is myopic to a certain extent, the other myopic to a greater extent.

5. *Mixed.*

In this variety one meridian is hypermetropic, the other myopic.

It is said that unequal contraction of the ciliary muscle, a power involuntarily acquired by an astigmatic person, compensates for moderately unequal curvatures of the cornea. Such power is exercised at the expense of considerable nervous energy. In case the inequalities of curvature remain uncorrected by the accommodation of the patient, vision must be more or less impaired. An astigmatic person sees a point not as a point but as a line. Suppose, for instance, an eye to be emmetropic in the vertical meridian and hypermetropic in the horizontal. Such an eye, its accommodation being at rest, if fixed upon a point of light would see the light not as a single bright spot but as a more or less elongated streak of dim light. The rays which have passed through the vertical (or emmetropic) meridian have focused accurately upon the retina, but the rays which have passed through the horizontal (or hypermetropic) meridian have not yet been brought to a focus and so produce an indistinct horizontal line.

An astigmatic eye which is fixed upon a series of lines arranged in the form of a clock dial (as in the contrivance commonly used for testing astigmatism) sees clearly only those lines which are at right angles to its better meridian.

Suppose, again, an eye to be emmetropic in the vertical meridian and hypermetropic in the horizontal. Such an eye fixed upon the clock dial of lines will see the horizontal lines quite clearly, while the vertical lines will be blurred. The clear perception of a line depends upon the distinct

marking of its edges. The rays emerging from the vertical lines pass through the vertical and through the horizontal meridians of the eye in question. The vertical meridian focuses them accurately upon the retina, but the horizontal meridian vitiates this result by failing to bring to an accurate focus the rays which have passed through it. Consequently, on either side of the distinct line formed by the emmetropic vertical meridian there is a blurring which destroys the sharp edge of the line. Therefore, although the vertical meridian is the better one, the vertical line is the less distinctly seen.

On the other hand, an eye such as that taken for an example will see horizontal lines distinctly. The rays from the horizontal lines pass through the vertical meridian and are accurately focused upon the retina. Rays from the same lines pass through the horizontal meridian and are superimposed upon the line already formed by the rays which have passed through the vertical meridian. Only at the ends of the line is fraying or indistinctness perceptible.

Astigmatism at other axes than the directly vertical and the directly horizontal can be ascertained by the clock-dial test.

The *Clinical Symptoms* of astigmatism are those of asthenopia. Violent headache is a frequent complaint, and patients are often relieved immediately on beginning to wear their correcting lenses. An astigmatic patient often habitually twists his head in trying to get a clear image of an object, from his desire to so adapt the meridians as to overcome as much distortion and indistinctness as possible.

**IV. Presbyopia.**

Properly speaking, this is not an error of refraction, but inasmuch as it is a condition of the eye which requires correction by lenses, it may be classed under this head.

Presbyopia may be defined as that condition of the eye in which the power of accommodation is either partially or wholly lost.

Failing accommodation is dependent upon an increasing rigidity of the lens. In early life, the elasticity of the lens allows it to become somewhat more convex in accordance with the refractive power required for the clear perception of near objects. Formerly, presbyopia was considered to be due, in part at least, to loss of contractile power in the ciliary muscle. This theory is not tenable, for the contractility of the ciliary muscle in the old has been found in the majority of cases to compare favorably with that in the young.

No age can be arbitrarily assumed as that at which presbyopia begins. A hypermetropic eye presents symptoms of presbyopia earlier than the emmetropic or than the myopic eye, for the hypermetropic eye is obliged to exert a certain amount of its accommodative power all the time to overcome its error of refraction, and so has less in reserve for that time when accommodation fails to respond to demands made upon it.

The average reading distance is assumed to be about 33 cm. (13 inches). When the habitual near point recedes beyond this limit, presbyopia is said to have set in. A strong enough convex lens must be given to enable the patient to work without effort at his ordinary working distance. People who are able to read with comfort without glasses after the age of forty-five or fifty, must have a certain degree of myopia. A patient with myopia of 3 D. will have a far point of distinct vision at thirteen inches, the ordinary reading distance. He will always be able to read without glasses at this distance, unless some disease of the eye supervene.

It is not worth while to quote tables showing the rate of diminution of accommodative power and the correcting

lenses required at certain ages. Each patient should be studied as an individual case, as there may be many reasons in the refractive condition of his eye to explain his lack of conformity to any arbitrarily constructed table.

The *Clinical Symptoms* of presbyopia are those of failing vision for near work. The patient complains of not being able to read with comfort, or of having difficulty in threading a needle. Symptoms of asthenopia may accompany these complaints.

## CHAPTER IV.

### THE CORRECTION OF ERRORS OF REFRACTION.

Certain technicalities occur in the formulæ employed in ophthalmology. They are explained thus :—

1. O.D. stands for *oculus dexter*, right eye.
2. O.S. stands for *oculus sinister*, left eye.
3. S. or Sph. stands for *sphere*.
4. C. or Cyl. is an abbreviation for *cylinder*.
5. The sign of *combination* is ⊂.
6. The word *axis* is usually shortened to "ax."
7. D. stands for *diopter*.

The following formula, together with its translation, may be useful as an example :—

$$+ 1.00 \text{ D. Sph.} \subset - 0.50 \text{ D. cyl. ax. } 90°.$$

It should be read in this way: A plus one-diopter sphere, combined with a minus one-half diopter cylinder, axis ninety degrees.

**Simple Hypermetropia** (H) is corrected by a convex sphere. The hypermetropic eye at rest would bring all rays to a focus behind the retina. A convex lens of a strength equal to the deficiency in the refractive power of the eye brings the rays to a focus upon the retina.

**Simple Myopia** (M) is corrected by a concave sphere. The condition is the reverse of hypermetropia.

**Hypermetropic Astigmatism** (HAs) is corrected by a convex cylinder, the axis of which should be in the direction of the emmetropic meridian, and the strength of which

equals the amount of hypermetropia in the ametropic meridian.

**Myopic Astigmatism** (MAs) is corrected by a concave cylinder. The condition is the reverse of hypermetropic astigmatism.

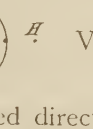
**Compound Hypermetropic Astigmatism** (CoHAs) requires a convex lens for one meridian and a stronger one for the other meridian. By using a sphere to correct the lesser amount of hypermetropia (and this sphere will, at the same time, correct a part of the error in the more hypermetropic meridian), and by then adding a cylinder with its axis placed in the direction of the corrected meridian, and of sufficient strength to overcome the yet uncorrected hypermetropia in the opposite meridian, the error is overcome.

**Compound Myopic Astigmatism** (CoMAs) is the reverse of compound hypermetropic astigmatism, and requires for its correction a concave sphero-cylinder.

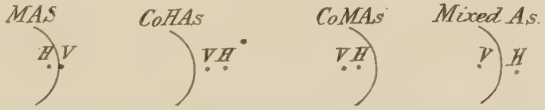
**Mixed Astigmatism** requires a convex lens for one meridian and a concave lens for the other meridian. Two cylinders, with their axes at right angles to each other, correct the error, but such a glass is ground at considerable expense, and is not so easily worn as a sphero-cylinder. It is best, therefore, to correct one meridian by a sphere; then to add a cylinder with its axis in the direction of the corrected meridian, and of sufficient strength to both offset the effect of the sphere upon the opposite meridian, and at the same time to overcome the ametropia as yet uncorrected. For example: Suppose an eye to be myopic in the vertical meridian to the extent of 2D, and hypermetropic in the horizontal meridian to the extent of 3D. A minus 2D sphere corrects the vertical meridian, but causes the hypermetropic meridian to be still more hypermetropic by 2D. Therefore, the cylinder to be added (axis in the direction of

the corrected meridian) is a plus 5D. Similarly, the hypermetropic meridian may be corrected first, and a minus cylinder added (axis horizontal) of sufficient strength to correct the myopia of the vertical meridian and to also neutralize the + 3D used to correct the horizontal meridian.

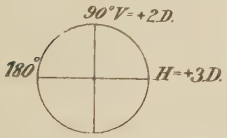
In studying the refractive conditions of the eye, one may represent the retina by a curved line, and then represent by a dot the focal point of each meridian.

For instance, 

V = the vertical meridian, by which rays are focused directly upon the retina. H = the horizontal meridian, by which rays would be focused behind the retina. This is HAs.

Similarly, 


Or the cornea may be represented by a circle, and the principal meridians indicated by lines drawn at right angles to each other, thus :—




This is CoHAs, corrected thus :—

+ 2D. Sph. ⌒ + 1.00 cyl. ax. 90°,

or (to express the correction in a different way) + 3D. Sph. ⌒ — 1.00 cyl. ax. 180°. The former glass is the better one to order, because it is the more simple. Any refractive conditions may be worked out by using diagrams, and in this way facility may be gained in the use of formulæ and in writing prescriptions for glasses.

The principal meridians may not be directly vertical and

horizontal, and the student should familiarize himself with the inclinations of axes lying between 0 and 180. For example, the cornea may be represented by the circle as before, but the lines drawn thus:


and the axes marked respectively 110° and 20°.

A convenient rule for finding the opposite of a given axis is this:—

*If the given axis is a number less than 90, add 90 to it to find the opposite axis; if the given axis is a number greater than 90, subtract 90 from it.*

The conversion of one formula into another is often necessary in cases in which different signs occur.

For example,

$$+ 1.\ \text{D. Sph.} \supset - 3.\ \text{cyl. ax. } 90°.$$

This glass is equivalent to

$$- 2.\ \text{D. Sph.} \supset + 3.\ \text{cyl. ax. } 180°,$$

as one may work out by diagram:


A convenient rule for this conversion saves one the necessity for working out the problem by diagram:—

*Subtract the less from the greater, and to the result prefix the sign of the greater; combine with cylinder of the same strength as before, but use opposite sign and opposite axis.*

**The Correction of Presbyopia** is accomplished by a convex glass strong enough to bring the near point of distinct vision to the required distance. This required distance varies according to the habits and occupations of patients. One should always examine a presbyopic patient for his so-

called "static" error of refraction, *i. e.*, the amount of hypermetropia, myopia, or astigmatism existing in the eye apart from connection with the power of accommodation. The amount of this error added to the deficiency of the accommodation constitutes the full presbyopic correction.

**The Use of Mydriatics.**

In determining the refractive power of an eye, it is desirable to put the accommodation at rest. Tests made without the help of mydriasis are unreliable.

1. *Atropin* stands at the head of the list of mydriatics. It is especially to be recommended for the refraction of young people, in whom it is often difficult to produce complete mydriasis. The mydriatic strength is gr. ss of the sulphate to a fluidram of distilled water. One drop should be used in each eye three times a day for two days before the test is made. Its effects endure about ten days.

2. *Homatropin* is much used in office practice. It is seldom practicable in hospital clinics, owing to its expense and to the fact that it should be instilled by the physician every five or eight minutes until relaxation of the ciliary muscle is effected. Mydriasis lasts about two days. The strength usually employed is 1–40, although some use a solution of 1–20 and make only two, or at the most three instillations. The hydrobromate is commonly used.

3. *Duboisin.*—This drug is more transient than atropin, and is as effective. Many oculists prescribe it with caution because of its tendency to sometimes produce temporary mental aberration. The strength used is gr. ¼ of the sulphate to one fluidram of distilled water.

4. *Hyoscyamin* is practically the same as duboisin, and is used in exactly the same way. The hydrobromate is employed.

5. *Cocain.*—A 4 per cent. solution of the hydrochlo-

rate is used to produce mydriasis. Its effects are so transient, lasting less than twenty-four hours as a rule, that it is used in testing the refraction of the old, in whom dilatation of the pupil is requisite, but whose accommodation is either decidedly impaired or wholly lacking.

Cocain and homatropin are used in weak solutions to dilate the pupil for purposes of diagnosis.

**Examination of Vision** should be made—

1. Before the use of a mydriatic, and
2. While the eye is under the mydriatic.

The first records made concerning a patient should contain a statement of his visual power, both for far and near objects.

A card should be hung in a good light, from four to six meters distant from the patient. Lines of letters of graduated sizes serve as the test for distant vision, and above each line is registered, in terms of the meter, *the distance at which the line is read by the normal eye.*

The record of visual power is expressed by a fraction, the numerator of which is the distance at which the test is made, and the denominator the distance at which the line *should* be read by the normal eye. For example (see Fig. 7), suppose a patient to be situated at five meters from the card and to read nothing below the A T H Y E, etc., line. The record of his vision is $\frac{5}{10}$, the 5 expressing the number of meters at which the test is made, and the 10 expressing the number of meters at which this line is read by the normal eye. In case a patient can not see even the large E, which should be read at a distance of sixty meters, he should be asked to approach the card and to name the letter the moment he sees it. The distance at which he can recognize the letter serves as the numerator of the fraction, as before. Suppose this distance to be two meters.

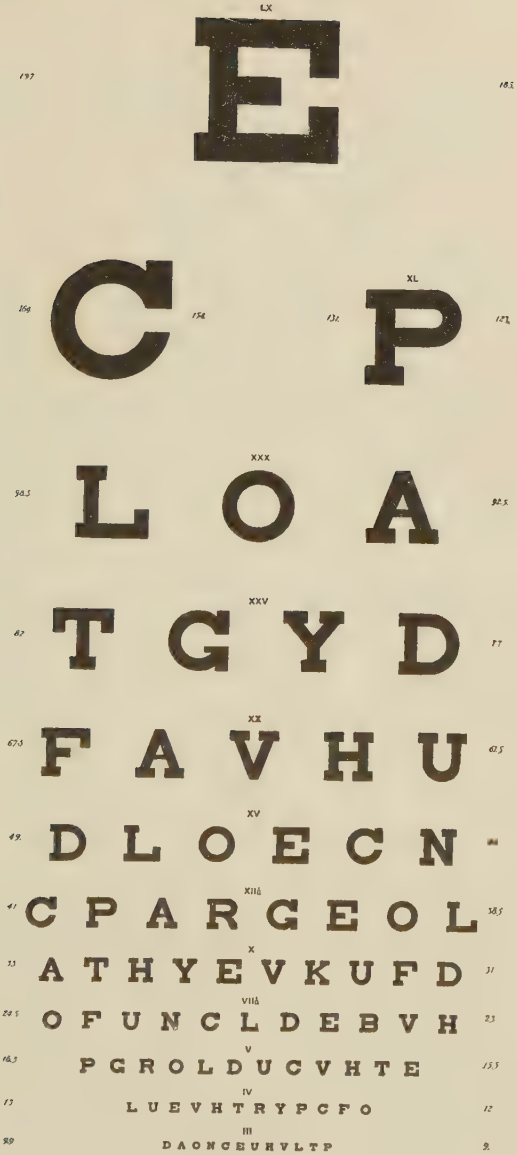



FIG. 7.
Arranged by Dr. A. Randall, of Philadelphia.

The record is then made thus: $V = \frac{2}{60}$. If the patient be unable to see the large E at any distance, the distance at which he can count fingers should be noted. For instance, if his right eye counts fingers correctly at 33 cm., but not beyond, the record is made thus: O. D. V = Fingers $\frac{1}{3}$ meter. If vision be so far gone that the patient can not even count fingers at any distance, his power to perceive shadows of objects moving before his eyes should be tested. By carrying the hand to and fro before such an eye, one can quickly decide as to whether the patient is conscious of the moving object. Failing in this, *light perception* should be tested by reflecting light upon the eye and watching carefully to find if the patient perceives the presence or the absence of the light. *Light projection* is tested by ascertaining if the patient can tell correctly the direction from which the light comes, whether from above, from below, or from either side.

In making a record of visual power, each eye should be tested separately; and while one is being tested the other should be covered by a card, as pressure upon it by the hand makes the record of its vision unreliable.

The test for accommodative power is made by means of small type, the best being that arranged by Snellen. The nearest point at which the patient can make out the letters or words of fine print (type 0.50 D), is called the *punctum proximum* (p. p.) and should be noted for each eye. The farthest point at which the type can be seen is called the *punctum remotum* (p. r.), and this is ascertained in a manner similar to that described for finding the near point. The record is made thus: O. D. Type 0.50 D. 12 cm.—45 cm., and similarly for O. S. In case a patient can not see the fine print at any distance (owing to presbyopia, most com-

monly), it is best to put a + 3. lens before the eye and record the result thus :—

O.D. + 3 D. Type 0.50 D 25cm.—70 cm.

These records express the *range of accommodation.*

The illiterate card enables us to obtain a fairly good idea of visual power in children and in uneducated persons. Upon the card is a series of geometrical figures graduated in size like the test-types. By explaining to the patient how to indicate by a movement of his hand the direction towards which the figures open or point, the vision can be quite accurately measured. (See Fig. 8.)

**How to Neutralize Lenses.**

If a patient brings with him glasses which he has been in the habit of wearing, they should be "neutralized" to determine their strength, *i. e.*, lenses of the opposite variety (either convex or concave) should be found whose strength is equivalent to that of the lenses under examination. One should hold a lens a few inches from the eye and look through it at some stationary object, such as a letter on the test-card. Then by moving the lens from side to side and up and down, one can quickly decide as to the kind of lens one is examining; for if it be a convex lens, the object looked at will seem to move in a direction *opposite* to that in which the lens is moved. If the lens be concave, objects seen through it will seem to move in the *same* direction as that in which the lens is moved. Suppose the lens under examination to be a convex sphere. Its strength is found by holding against it first one concave sphere and then another, until one is found which neutralizes the power of the convex sphere, the combination of the two spheres being now equivalent to plane glass. If a lens contains both a sphere and a cylinder, one meridian of the glass should

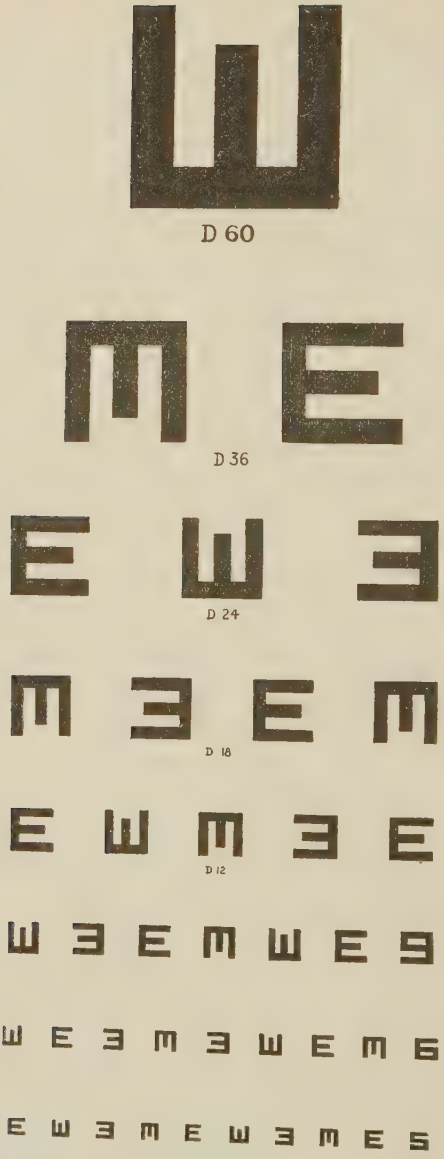



Fig. 8.

first be neutralized by a sphere, and then the other meridian by a cylinder with its axis in the direction of the neutralized meridian, all three lenses being held together and moved quickly in all directions in order to detect any un-neutralized power. A simple cylinder will give movement in one direction only, that at right angles to its axis. It is often very difficult to neutralize a complex lens, particularly when the axis of the cylinder is unusual. The student will find the clock-dial card a help in neutralizing such lenses. He should find the glass which renders clear lines running in a certain direction. This direction indicates the neutralized meridian and the axis of the cylinder required to render the other lines clear.

The apparent movement of objects seen through lenses may be explained by study of the properties of prisms, every lens being practically made up of a series of prisms with their bases turned either towards or away from the center of the glass.

While the eye is under a mydriatic, the static refraction of each eye should be determined as quickly as is consistent with accuracy ; for the retina, which, because of the wide dilatation of the pupil, is receiving more light than usual, soon tires and fails to respond satisfactorily to tests. It is best to make an objective test first, preferably that of skiascopy. (See Chapter v.)

The exact or the approximate correction having been found, the trial at the test-case will be simplified and shortened. The patient should be seated at a distance of from four to six meters from the test-card, and the vision of each eye should be recorded before an attempt is made to improve it by lenses. A detailed explanation of the use of test-lenses would but burden the student's mind with rules and suggestions which would much better be learned by

practical experience under the personal supervision of an instructor. The art of refracting requires method, practice and judgment. The object is to find a glass which exactly corrects the ametropia in the eye; and, provided there is no loss of visual acuity through some defect, the eye should be fitted with a glass with which it can read $\frac{6}{6}$ and $\frac{6}{5}$ if possible. To this glass should be added in the prescription a minus .25 sphere; for while rays proceeding from objects four or more meters distant are assumed to be parallel, they are not actually so, but are slightly divergent. If the patient is given a glass which renders rays coming from objects four meters distant so convergent or so divergent (according as a convex or a concave glass is used) as to allow them to be accurately focused on the retina of the ametropic eye, rays proceeding from objects at a greater distance than four meters (and therefore more nearly parallel) will fail to be focused with the same accuracy upon the retina. The patient will be rendered slightly myopic for distance. This consideration is of especial importance in hypermetropic patients, but in myopic the slight lack of distinctness in distant vision would not be noticed. Suppose a record to stand thus :—

$$\text{O. D. } \frac{6}{36} + 2.\ \text{Sph.} \frown + 1.\ \text{cyl. ax. } 95^\circ = \frac{6}{5},$$

the *prescription* should be written thus :—

$$\text{O. D. } + 1.75\ \text{Sph.} \frown + 1.\ \text{cyl. ax. } 95^\circ.$$

Cases in whom accommodation is active, and whose error is corrected by high plus lenses, often require a reduction in the sphere of half a diopter or more, for on recovery from the effect of the mydriatic the ciliary muscle will refuse to entirely relax the tonic contraction which has been its habit, perhaps, for many years.

**Spasm of the accommodation** is comparatively rare, but occasionally a hypermetropic patient will be found whose ciliary muscle obstinately refuses to relax, and whose eyes, therefore, will not accept the correcting lenses. Such cases require reduction in the spherical part of the original prescription, and the addition every few months of as much stronger convex lens as the patients can accept. Myopic patients usually accept their full correction at once, although high minus lenses often so completely change the aspect of nature that patients find difficulty in adjusting themselves to the new relations.

# CHAPTER V.

## OPTICAL INSTRUMENTS AND THEIR USE.

### I. The Ophthalmoscope.

The most important instrument used in the examination of the eyes is the ophthalmoscope. Its invention is attributed to Helmholtz, who, in 1851, succeeded in constructing an instrument which revealed the details of the interior of the eye. Since that date the ophthalmoscope has been improved in many ways, until now an instrument is available with which it is possible not only to study the eye-ground, but also to estimate quite satisfactorily the refractive power of the eye. The principle of the ophthalmoscope, like that of almost all important inventions, is very simple. A mirror, with a hole in its centre, placed before an observer's eye and held close to the patient's eye in such a manner as to reflect light to the latter's eye-ground, will reveal the details of the fundus. But the ophthalmoscopes as at present constructed render examination of the interior of the eye more easy and satisfactory. A small mirror, oblong in shape, with a central circular opening four millimeters in diameter, is arranged so that one can tilt it from side to side and thus use to better advantage the rays of light proceeding from the lamp placed beside and behind the patient's head. A wheel provided with lenses is concealed in the body of the ophthalmoscope, and this can be revolved by the finger at the same time that the observer is studying the fundus. In this way lenses, either convex or concave, can be wheeled before the sight-hole of the

ophthalmoscope and so aid the observer in gaining a clear view of the eye-ground.

The patient should sit in a straight-backed chair, behind and somewhat at the side of which is a light, preferably an argand burner. He should look straight ahead and at some object on a level with his eyes, and the light should be

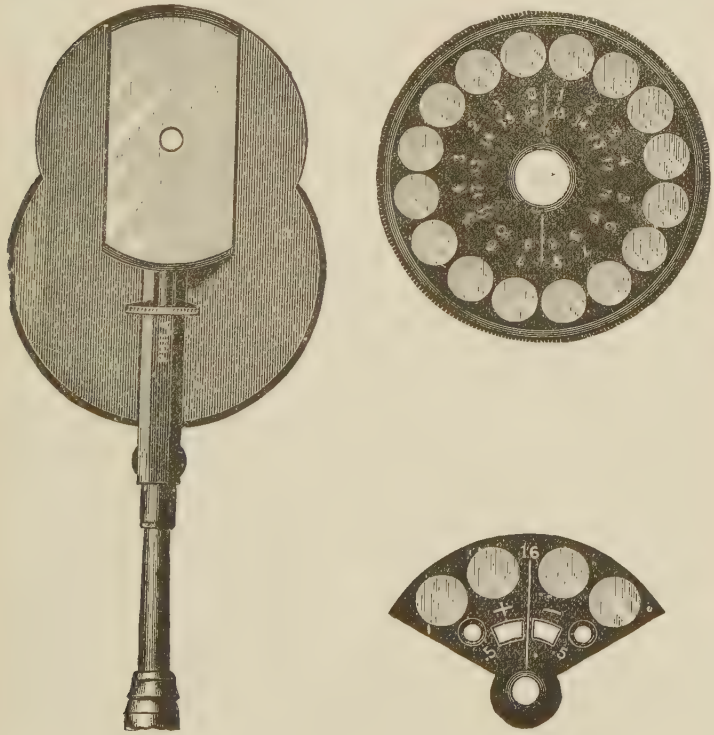


Fig. 9.—Loring's Ophthalmoscope.

placed behind him and far enough to the side to fall on the outer third of the eyelashes. This simple rule, suggested by Dr. Jackson, if habitually observed by the student, will help him to keep the fundus well illuminated during the examination. The observer should sit beside the patient in

such a position as to bring his own eye on a level with that of the patient, and to allow him to make the examination without leaning uncomfortably forwards.

Before trying to gain a view of the fundus, the observer should study with the ophthalmoscope the pupillary area of the eye. For this purpose the observer's eye should be at a distance of from twelve to sixteen inches from that of the patient. A convex lens wheeled before the sight-hole magnifies any defects which may exist in the media of the eye. The pupil having been illuminated by light reflected from the ophthalmoscopic mirror, any interruption of transparency of the media becomes noticeable. Striations in the lens appear as black marks of various sizes, shapes, and directions. Floating opacities in the vitreous appear as dark bodies, and can be diagnosticated as floating opacities by requesting the patient to turn the eye quickly in various directions and then to look straight forward, while the observer notes the fact that the bodies change their positions either slowly or rapidly, according to the condition of the vitreous humor. For a detailed examination of the media of the eye, dilatation of the pupil by homatropin or by cocain is often necessary.

The condition of the media having been ascertained, the observer's eye should be brought as near as possible to the patient's, and, provided the light is properly reflected, and the sight-hole is directly over the pupil, there is nothing to interfere with a view of the eye-ground. A beginner usually has difficulty in finding the nerve-head, or disk. He usually sees a blood-vessel first of all. By tracing this vessel to its source, he can soon find the disk. Owing to the magnifying power of the refracting media of the eye, the fundus appears enlarged about fourteen times. The average size of the normal disk is 1.5 millimeters. In estimating dis-

tances in the fundus, one usually speaks of a point as separated from another point by so many disk-diameters. The central retinal artery emerges from the disk, and, as a rule, it immediately divides into the inferior and superior branches. The artery and its branches are accompanied by veins. The veins are about one-fourth larger than the arteries, and darker in color, owing to the character of the blood they contain. Pulsation of the veins is often observed, and is not regarded as pathological, but pulsation of an artery is always significant of disturbance of the vascular system. Frequently a physiological cupping of the disk is observed, *i. e.*, a depression in or near its centre, caused by the branching of the inner nerve fibres upon a lower level than that of the more external ones. Pathological cupping of the disk will be described under GLAUCOMA. The size, shape, and color of the disk should be studied. Ability to discriminate between physiological and pathological conditions is acquired only by repeated observations and comparisons of many eye-grounds. Frequently the choroid does not so intimately surround the disk as does the sclera, and in such cases a "scleral ring" is observed. In choroidal disease this ring may be abnormally broadened. At the junction of sclera and choroid are often found accumulations of choroidal pigment. A "conus," or a "crescent" (according as it is more or less broad), of either complete or incomplete choroidal atrophy, is often seen bordering upon the disk, more frequently upon the temporal side. A conus is the usual accompaniment of myopia.

The general aspect of the eye-ground should be studied, and any abnormalities in retina, choroid, or sclera should be noted. Finally, the macular region should be observed. A view of this part of the fundus is best obtained when the patient looks for a moment into the light proceeding from

the ophthalmoscopic mirror. This movement of the eye brings the macula to about the same position that the disk occupied before. At the centre of the macula usually appears a small bright spot, the fovea centralis. There are very few vessels, or none, to be seen in its vicinity. Any evidences at or near the macula of atrophy, of hemorrhage, or of changes of any sort, bear an important relation to the vision of the patient, whereas similar disturbances in other parts of the fundus may exist without affecting vision for practical purposes.

A point of the fundus of an emmetropic eye emits rays which are parallel to one another after leaving the cornea, provided the accommodative power of the eye is at rest. Such parallel rays, passing through the sight-hole of the ophthalmoscope, enter the observer's eye, and (provided the accommodation is here also at rest, and his refraction emmetropic or corrected) are focused accurately upon his retina. If this parallelism of rays be affected by the accommodation of either one or both eyes concerned in the examination, or if ametropia exist in either one or both eyes, accurate focusing of rays does not occur, and consequently a blurred image of the patient's eye-ground is formed upon the observer's retina.

Therefore, requisites for a clear view of the fundus are—

(*a*) Absence of accommodative effort.

(*b*) Correction of ametropia.

Absence of accommodative effort on the patient's part can be induced by placing him in a darkened room and requiring him during the examination to look at a blank surface as far away as possible. Control by the observer of his own natural tendency to accommodate for near objects is gained only by practice, and even after he has learned by experience to relax his ciliary muscle completely,

there will be periods when he will be unable, because of physical or mental weariness, to depend upon his ability to control the tendency to accommodate, and at such times it will be impossible for him to correctly estimate the ametropia of a patient's eye.

Correction of ametropia in the observer's eye is best accomplished by his wearing his correcting lenses while he is making the examination. Ametropia in the patient's eye is corrected by a lens in the ophthalmoscopic wheel. In making an effort to see the patient's fundus, a beginner involuntarily accommodates, and thus renders himself artificially myopic. This condition is readily neutralized by the concave glass which corresponds to the amount of myopia which he has produced in his eye.

If the eye under examination be hypermetropic, a convex glass will be required to render the emitted rays parallel, and the highest convex glass with which the details of the eye-ground can be plainly seen is the measure of the hypermetropia. Similarly, in myopia the lowest concave glass which gives a clear view of the eye-ground is the measure of the error. Astigmatism is estimated by ascertaining the refractive power of the principal meridians of the eye. A blood-vessel running in a certain direction is selected, and the observer notes what lens of the ophthalmoscope gives the clearest view of this vessel. A vessel running at right angles to the first chosen is then found and a note made as to the lens which best brings it into view. The difference between these two lenses is the measure of the astigmatism.

Ametropia at the macular region should be measured, if possible, since that part of the eye is most used in practical vision.

**II. The Convex Lens.**

(*a*) Indirect examination.

In this method the ophthalmoscope is supplemented by a high convex lens (about 14 D.). The position of the observer is the same as that assumed for examination of the media. While the pupil is illuminated by rays reflected by the ophthalmoscopic mirror, the observer, holding the convex lens between the thumb and forefinger of the hand not occupied with the ophthalmoscope, places the lens before the patient's pupil, directly in the path of the light rays. On focusing, an aërial inverted image of the fundus is obtained. This image is much smaller and more distinct in myopia than in hypermetropia. This method is valuable chiefly in cases of high myopia, when it is difficult to get a satisfactory view of the fundus by the direct ophthalmoscopic method.

(*b*) Oblique illumination.

This method of examining the external part of the eye is of especial use in the detection of foreign bodies in the conjunctiva or cornea, and of opacities in the cornea ; also in the study of the anterior chamber and the anterior portion of the lens. The patient is seated in such a position that the light shines full upon the side of his face. A high convex lens is then placed in the path of the rays, and by it the light is concentrated upon the eye. By moving the lens slightly in different directions, portions of the anterior part of the eye can be satisfactorily illuminated and studied.

**III. The Skiascope.**

The skiascope at present employed is a plane mirror with a small central hole about as large as that of the ophthalmoscope. The mirror is mounted upon a handle. A concave mirror may be employed, but as the plane mirror

offers many advantages it is now commonly used. Dr. James Thorington, of Philadelphia, recommends a small mirror 2 cm. in diameter, mounted upon a black disk 4 cm. in diameter, claiming that light can be concentrated to better advantage than by the larger mirror.

Skiascopy (also called fundus-reflex test, shadow-test, retinoscopy) is the most important objective test used in refraction. To obtain from it results which are accurate and reliable, one must become skilled in its use, and this implies an amount of practice which comparatively few are

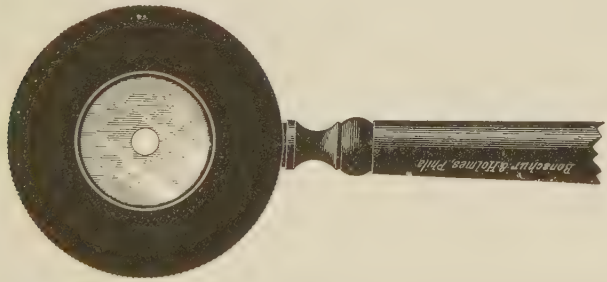


FIG. 10.—SKIASCOPE.

willing to devote to it. The principles governing skiascopy are simple, but the reasons for many of its phenomena are complex. Dr. Edward Jackson has done more than anyone else to give the test the prominence which it deserves.*

The practice of skiascopy requires, in addition to the skiascope itself, a special shade for the lamp chimney. This shade is made from metal or from asbestos, and is of the same shape as the glass shade. It fits quite closely over the glass chimney, and at a point opposite the brightest part of the flame there is a round hole one centimeter

* See "Skiascopy," by Edward Jackson, A. M., M. D., pub. by The Edwards Docker Co., Phila.

or less in diameter. Through this hole pass rays which are caught and reflected by the skiascope. The examiner sits very near the light and reflects the rays to the eye of the patient, who is seated at one meter's distance opposite the examiner. To the observer's eye, which is behind the sight-hole of the skiascope, the pupil of the patient appears as a brightly illuminated area. If the mirror is now turned slightly from side to side, or up and down, the light area will be stationary, or will follow the movement of the mirror, or will move in a direction opposite to that of the mirror.

The rays reflected from an emmetropic eye at rest are parallel. A convex glass of one meter's focal distance (1 D) must be put before such an eye in order to render the returning rays convergent to a focus or "point of reversal" one meter from the patient's eye, or at the eye of the observer. If the test were being made at one-half a meter, a 2 D lens would be needed. Now, when rays proceeding from an eye are thus focused at the observer's eye he cannot detect any movement of the light area in the pupil. Therefore, the correction of all movement of the light area is the ideal to be attained in skiascopy.

In hypermetropia the rays return from the eye divergent. An observer may place his mirror anywhere within the cone of rays emerging from the hypermetropic eye and may note that in whatever direction he moves his mirror the light area in the pupil seems to follow. In myopia of more than 1 D the light area seems to move in a direction opposite to that of the movement of the mirror. Rays reflected from a myopic eye are convergent and cross one another at the "punctum remotum." If a patient have myopia of more than 1 D, his far-point lies somewhere within one meter's distance from his eye. An observer situated at one meter's distance from such a

patient perceives that as he moves his mirror in a certain direction the light area in the pupil seems to move in the opposite direction.

The ametropia is corrected by placing a sufficiently strong convex or concave lens (as the case may be) before the patient's eye to converge the rays to the situation of the observer's eye. But this lens is not the measure of the *actual* refraction of the eye, but represents the error *as appreciated at one meter's distance.* To every skiascopic correction obtained at a distance of one meter a minus 1 D lens must be added.

The presence of astigmatism in an eye is appreciated by the fact that the movement in one direction has a certain degree of rapidity, while that at right angles to it has a certain greater or less degree. The slower the movement the higher the error, and *vice versa.* Each principal meridian may be corrected by a sphere, and the two correcting lenses be combined in a sphero-cylinder; or the meridian of less error may be corrected by a sphere, and to this may be added a cylinder with its axis in the direction of the corrected meridian and of sufficient strength to correct the remaining ametropia. A phenomenon of astigmatism is the appearance in the eye of a band of light with its axis at right angles to the direction of its movement. The band is best seen when one principal meridian of the eye has been corrected by a sphere and the other meridian remains only partially corrected. The direction of the band corresponds to the axis of the cylinder to be used for the correction of the astigmatism.

Mixed astigmatism and irregular astigmatism can be quickly diagnosticated by means of the skiascope. The subjective test is greatly facilitated by obtaining by this method even an approximate idea of the lenses required.

### IV. The Perimeter.

This instrument is used for ascertaining the state of retinal sensibility in portions of the eye-ground peripheral to the macula. The perimeter is mounted upon a standard and is provided with a rest for the chin of the patient, who should be seated while the test is being made.

The essential part of the perimeter is a metal semi-circle upon which regular intervals of distance are marked. The semi-circle turns at its center upon a pivot, and opposite this pivot, at the inner side, is a small white disk upon which the patient's gaze is to be steadily fixed during the test. Surrounding the pivot is a metal wheel on which are indicated the degrees of the angle through which the semi-circle is turned from time to time. Upon the perimeter are two "travelers," metal contrivances, each having a round hole in which can be exposed disks of pasteboard of different colors. These travelers slide easily upon the semi-circle; one is used for the upper part and one for the lower part. The instrument and also a chart, upon which can be recorded the results obtained during the test, are illustrated in Figs. 11 and 12.

The patient having been seated before the perimeter, his chin upon the rest, and the eye to be tested gazing at the "fixation point" at the middle of the semi-circle (the other eye being excluded from vision), the semi-circle is placed in a vertical position (at 90°), and the upper traveler is made to slowly approach from the upper extremity of the perimeter towards its center. The moment the patient perceives the white or colored pasteboard in the round hole of the traveler, the gradation marked upon the semi-circle at this point is noted on the chart. A similar test for the upper part of the retina is made with the lower traveler. The semi-circle is then turned at a slight angle and the test

repeated; and so on, until the peripheral limits of perceptive power in all parts of the patient's retina have been found. The test is then repeated for the other eye.

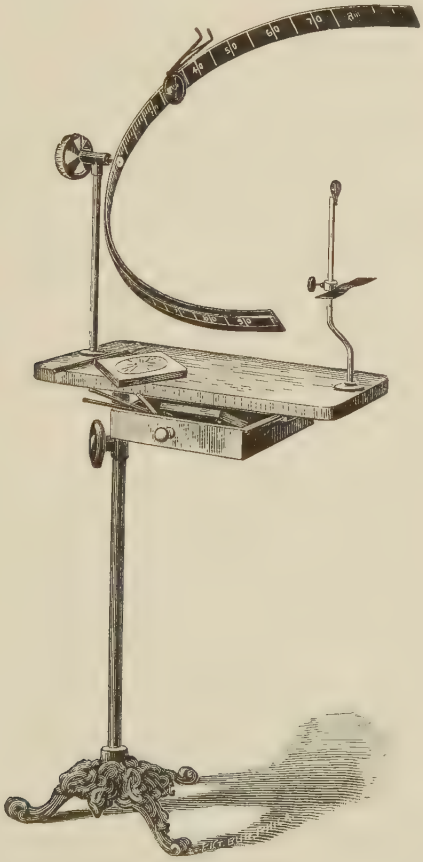
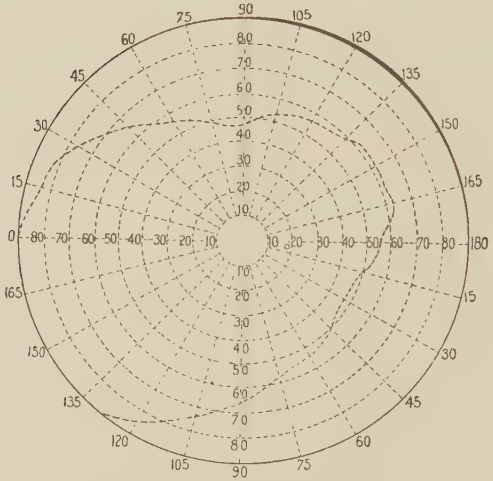


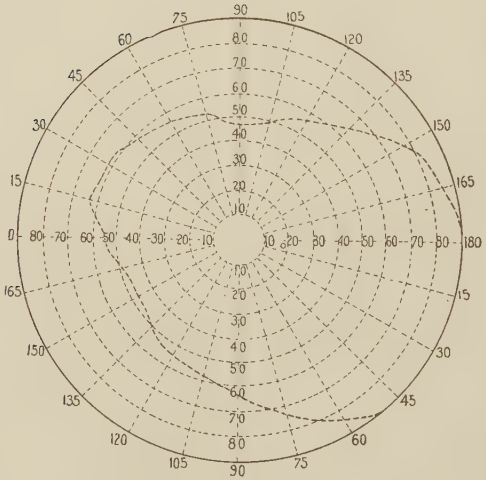
FIG. 11.—PERIMETER.

The field for white is largest; next in order come blue and yellow, then red and green.

The temporal field of vision is more extensive than the




Normal Field for White, Left Eye.




Normal Field for White, Right Eye.

FIG. 12.—PERIMETER CHART.

nasal, because the nose cuts off many rays that would otherwise enter the eye.

Contraction of the field of vision is an important diagnostic feature in certain diseases. The contraction may be uniform or may be irregular in character. *Hemiopia* is absence of retinal perceptibility in one-half of the visual field. *Scotomata* (sing., scotoma) are demonstrable breaks in the visual field. They are often spoken of as "islands." They represent loss of perceptive power in the retina at certain parts, and may be either central or peripheral. The disturbance of sight which they produce is dependent upon their situation and size. A *positive* scotoma is perceived by the patient as a dark spot before his vision. The cause of this variety of scotoma may be an opacity in the media, or may be due to disease of the retina. A *negative* scotoma is appreciated by the patient as a definite area within which no image of external objects is perceived. One of the most frequent varieties of scotoma is that due to recent poisoning by tobacco, in which there is loss of perceptive power at the macula. This is called *central* scotoma. This loss of perceptive power may not be experienced for white, but if a red disk be held before the patient, he will fail to recognize the color in the central area of the disk. The physiological "blind spot" may be located by means of the perimeter. It represents the point of entrance into the eye of the optic nerve.

**V. The Ophthalmometer** is an instrument for the determination of the presence and the amount of corneal astigmatism. A telescope is supported by an upright bar with a movable tripod base. Within the telescope at the focus of the eye-piece are two fine cross hairs ; the telescope is also furnished with a bi-refrigerant prism. To the large end of the telescope is attached a graduated arc, upon which are

two objects called targets, or mires, one of these (the left) being fixed, while the other is movable. Each target is a

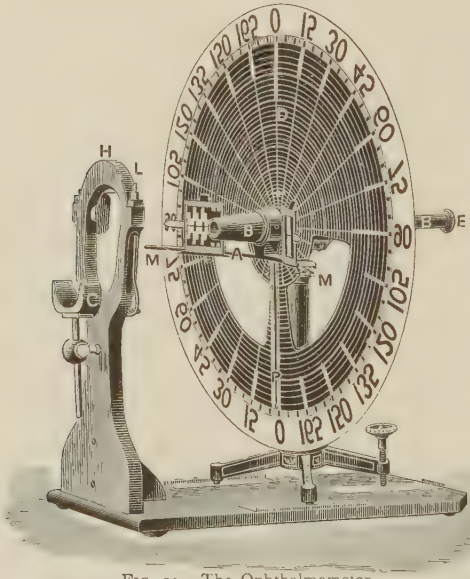



Fig. 13.—The Ophthalmometer.

parallelogram in shape, but one is cut away in steps [A, B.]. At the outer side of each target is a small pointer. A much

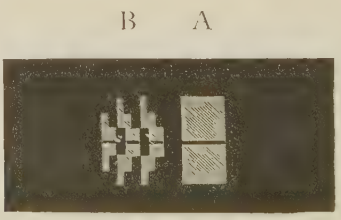



Fig. 14.

larger pointer is attached to the telescope at about its center. The telescope passes through the center of a large

graduated disk. Opposite the telescope is a rest for the patient's head, and a small shade which is used to cover the eye not under examination. In testing, the ophthalmometer should be so placed that a strong light falls upon the disk. The patient's head having been placed in position, the eye to be tested should look into the telescope. The observer now brings the patient's eye into the field of the telescope and into focus by moving the tripod base of the instrument backwards and forwards. The targets and the disk are now reflected upon the patient's cornea. Because of the prism in the telescope, there appear to the observer's eye four images of the targets. The outer ones

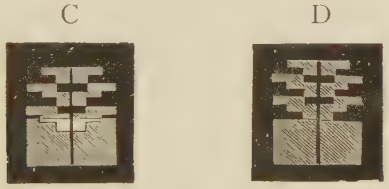



FIG. 15.

are to be disregarded. The telescope should now be rotated so as to bring the long pointer to the zero mark on the disk. The left target is now brought into the center of the field, so that the cross hairs seem to divide it into four equal parts. Then the second target is made to slide along the arc until its edge seems just to touch, but not to overlap that of the first one [D].

The telescope should now be slowly rotated. If astigmatism be present, the target images will either separate or overlap (A, B ; C). The point of greatest separation or overlapping is found and the graduation upon the disk as indicated by the large pointer is noted. This expresses the direction of one of the principal meridians of the cornea. The

extent of the separation or overlapping indicates the amount of astigmatism, each step of the target image being equivalent to one diopter. The extent of overlapping or separation is best found by noting the number of graduations upon the arc that are passed over when the target is moved along just far enough to bring the edges of the two images together as at the beginning of the test. In case of overlapping, the small pointers indicate the meridian of greater curvature, while in case of separation they indicate the meridian of less curvature.

**VI. Placido's Disk.**

This contrivance is seldom used, as many other methods for recognizing astigmatism have taken precedence. It is a white disk about ten inches in diameter, upon the surface of which are painted concentric black rings, one inch apart. There is a central opening through which the observer looks. The disk is held upright before the eye to be examined, and the image of the rings is reflected upon the patient's cornea. If to the observer the rings appear elliptical, regular astigmatism is present ; if the rings appear distorted, irregular astigmatism is present.

## CHAPTER VI.

### THE OCULAR MUSCLES.

A review of the anatomy of the ocular muscles will help the student to analyze the various movements of which the eye is capable. The muscles are grouped, with respect to function, as follows :—

| | | |
|---|---|---|
| The *abductors* are | (*a*) The external rectus. | |
| | (*b*) The two oblique muscles. | |
| The *adductors* are | (*a*) The internal rectus. | |
| | (*b*) The superior and inferior recti. | |
| The *elevators* are | (*a*) The superior rectus. | |
| | (*b*) The inferior oblique. | |
| The *depressors* are | (*a*) The inferior rectus. | |
| | (*b*) The superior oblique. | |
| The *rotators* are | (*a*) Superior oblique. | Upper part of eye turned inward. |
| | (*b*) Superior rectus. | |
| | (*c*) Inferior oblique. | Lower part of eye turned inward. |
| | (*d*) Inferior rectus. | |

#### The Innervation of the Ocular Muscles.

1. By the *third* nerve (oculo-motor) are supplied all the muscles of the eye, except the external rectus and the superior oblique.

2. By the *fourth* nerve (trochlear) is supplied the superior oblique.

3. By the *sixth* nerve (abducens) is supplied the external rectus.

The nuclei of these nerves lie on the floor of the fourth ventricle, the most anterior nucleus being that of the third nerve. Just behind the nucleus of the third nerve lies that of the fourth, while the nucleus of the sixth nerve lies far

behind the other two nuclei. The nucleus of the facial nerve and that of the sixth are in close proximity.

The affections to which the ocular muscles are liable may be classified thus :—

1. Insufficiency.
2. Strabismus.
3. Paralysis.

**I. Insufficiency.**

The eyes are said to be "balanced," or in equilibrium, when the visual axis of the one meets the visual axis of the other at the point of fixation, *i. e.*, the object looked at. This equilibrium may be a natural state, or it may be one maintained at the cost of nervous energy. Insufficiency means relative weakness of a muscle.

The tendency of an eye towards deviation is shown, as a rule, by the "cover test." The patient is told to fix his gaze upon some distant object. While he looks steadily at this object, a card is placed before one of the eyes and a moment afterwards withdrawn. If the eye has a tendency to deviate, it will wander out or in while under cover, and when the card is withdrawn it will make a quick movement of recovery, so as to cause the image of the distant object to fall upon the macula as in the other eye. This test should be tried both for distance and near. Many ophthalmologists claim that unless the insufficiency becomes apparent by this test, there can not exist in the eye an amount of muscular trouble necessary to note. But the cover test is not always reliable. By far more satisfactory is the test with prisms.

A prism always deflects rays towards its base. A prism, for example, placed with its base down before an eye, will so bend the rays entering the eye as to cause them to meet the retina at a point farther down than would have been

the case had they not been interrupted in their course. Rays meeting the retina below the optical axis (or center of the eye) are referred by the mind to a point outside the eye at a distance equivalently above the optical axis. This habit of judging of the positions of objects is a mental acquirement. We are accustomed to speak of objects whose rays impinge upon the nasal side of our retina as situated upon our temporal side, and *vice versa*.

Binocular single vision is experienced when both eyes are fixed upon the same object, the rays from which impinge upon such parts of each retina as correspond to each other. An obstacle to binocular single vision may be offered through so simple a medium as a colored glass. A red or a blue glass placed before an eye may, in cases of unstable equilibrium, cause double vision (diplopia), the one image seen being red or blue, the other of normal color. Even in cases of stable muscular equilibrium diplopia may be induced by the use of a prism, the strength of which varies, however, with the muscle or set of muscles to be influenced. The externi have a power equal to a prism of eight degrees; the interni can overcome a prism of twenty-three degrees; while the superior and inferior muscles have a power equal to a prism of only three degrees.*

Certain technical terms are employed in referring to ocular-muscle tests.

*Hyperphoria* means that condition in which one eye has a tendency to deviate to a higher level than that of its fellow.

*Exophoria* signifies a tendency to deviate outwards.

*Esophoria* signifies a tendency to deviate inwards.

*Homonymous diplopia* is that variety of double vision in

* These are conclusions reached by Dr. S. D. Risley. See *University Medical Magazine*, January, 1895.

which the image seen on the right belongs to the right eye, and *vice versa.*

*Crossed diplopia* is that variety of double vision in which the image belonging to the right eye is seen on the left of that seen by the left eye, and *vice versa.*

When one places a prism of 10°, for instance, before the right eye, base in, the rays entering the eye are deflected to the nasal side of the retina. The natural desire for single vision stimulates the external rectus to contract, and by this means to bring the macula more nearly within reach of the deflected rays. But since the external muscles can, as a rule, overcome no stronger prism than one of eight degrees, a 10° prism, base in, produces inevitable double vision. The deflected rays, then, continue to impinge upon the retina at the nasal side of the macula, and the image thus formed is referred by the mind to the temporal side of the outside world. In insufficiency of the external rectus, therefore, *homonymous diplopia* is experienced. The reverse of this result might be shown by placing before the eye a prism, base out, of sufficient strength to overcome the internus. But the prism would be too heavy to prove practicable. The artificial production of homonymous diplopia is sufficient for testing purposes.

The patient should be seated at a distance of six meters from the light which is to serve as test object, and the light should be on a level with the patient's eyes.

**Test for Hyperphoria.**—A trial-frame having been carefully adjusted before the patient's eyes, an artificial diplopia should be produced by placing a 10° prism, base in, before one eye, and a red glass should be put before the other eye. If the eyes are in equilibrium so far as upwards or downwards deviation is concerned, the two images now perceived by the patient will be upon an exact level. If,

however, one image be higher than the other, it follows that one eye has deviated more or less upwards or downwards. The condition is named from the lower image, since it belongs to the higher eye. For instance, if the red image be the lower one and the red glass before the left eye, the deviation is called *left hyperphoria*. The next step is to find how strong a prism is required to bring the two images to the same level. This prism is the measure of the hyperphoria; but since the real power of a prism is equal to about one-half its apical angle, the record of deviation on the part of the eye must be one-half the number engraved on the prism.

**Test for Exophoria and Esophoria.**—An artificial hyperphoria is produced by placing a prism of 6°, base up or down, before one eye, and a red glass is placed before the other eye. If the eyes are in equilibrium so far as their tendency to deviate outward or inward is concerned, the two images now seen by the patient will be one above the other, the one being neither to the right nor to the left of the other. Should the left image be situated on the right-hand side, crossed diplopia is present, and an insufficiency of the interni exists. On the other hand, if the left image is on the left of the right eye's image, homonymous diplopia and insufficiency of the externi are present. It only remains to find how strong a prism is required to bring the two images directly one above the other. As before, one-half the number engraved on the prism should be recorded as the measure of the deviation.

*The Maddox Rod* is a cylindrical glass rod placed in a metal disk of size convenient for use in the trial-frame. When this rod is placed before the eye of a patient seated six meters from a light, the actual form of the light will be seen by the uncovered eye, while by the eye behind the rod

it will be seen as a long, narrow streak. The two images thus produced are so dissimilar that there is no tendency on the patient's part to fuse them. If the rod be placed horizontally before the eye, a vertical streak of light is produced. If this line of light appears to the patient to pass through the flame seen by the other eye, lateral *orthophoria* (muscular equilibrium) exists. But if the line of light be on either side of the flame, lateral *heterophoria* (either exophoria or esophoria) is present. Similarly, if the rod be placed vertically before the eye, the line of light will be horizontal in direction and will either seem to pass directly through the flame or to be above or below the flame, according to the state of muscular power in the eyes under examination. The prism which in any case causes the line to intersect the flame is the measure of the muscular insufficiency, and one-half the number engraved on the prism represents the amount of heterophoria in the eyes.

Rotary prisms have been devised which simplify the ocular-muscle tests.* Dr. G. T. Stevens, of New York, who introduced the term "phoria" (a tendency) and its prefixes, devised a phorometer by whose use the degree of insufficiency existing in a muscle can be quickly found.

The chief cause of insufficiency of the ocular muscles is ametropia. Insufficiency of the interni sometimes develops as an accompaniment of myopia, and insufficiency of the externi frequently accompanies hypermetropia. Various forms of nervous disturbance can be traced to faulty muscular power, and complete relief from headache and symptoms of eye-strain is often not obtained until appropriately

* For description of Dr. Risley's, see *Transactions of the American Ophthalmological Society*, 1889. For description of Dr. Jackson's, see *Transactions of Section on Ophthalmology*, American Medical Association, 1893, and *Archives of Ophthalmology*, 1894, No. 1.

placed prisms are combined with the lenses which correct the patient's focal error.

**II. Strabismus.**—Strabismus (also called "squint") is an outgrowth of insufficiency, the difference between the two conditions being only one of degree. Insufficiency is a latent or corrected squint, while squint proper is a manifest or uncorrected insufficiency. Strabismus may be either *periodic* or *constant;* it may be present only when the patient looks at a near object, or only when he looks at a distant object, or it may be present for all distances.

*Concomitant* strabismus is that variety in which the movements of one eye correspond in amount to the movements of the other eye. In *paralytic* strabismus, on the contrary, one eye lags behind the other when the eyes are turned towards the side of the paralyzed muscle. The differential diagnosis of these two varieties of strabismus is made by use of the cover test.

Suppose a case in which the right eye habitually squints inward. The patient is requested to look at some object on a level with his eyes, and the position of the external margin of the cornea of each eye is indicated by a dot of ink on the margin of the lower lid. Now a card is held before the left eye, and the patient is told to try to find the object by using the other eye. The right eye will make an effort to fix, and when it has become stationary the external margin of the cornea is again indicated on the lower lid. At the same time the external margin of the cornea of the eye behind the card is similarly indicated. If the squint be concomitant, the left eye has made a movement equal to that made by the squinting eye in its effort to fix. The ink-marks upon the lid of the squinting eye show the *primary strabismic deviation*, while those upon the lid of the other eye show the *secondary strabismic deviation*, and each of

these two intervals is equal to the other. This method of measurement is called the "linear;" one millimeter of the linear measurement is equal to an angle of about 5°. In paralytic strabismus, secondary deviation is always greater than primary.

In the *alternating* form of concomitant strabismus (*i. e.*, when either eye fixes), the visual acuity of one eye may not be appreciably below that of the other. But eventually, through some defect in one eye or because of a greater amount of ametropia in it than in the other, the better eye habitually fixes. The visual acuity of the eye whose images the mind soon learns to exclude becomes notably affected, and may become "amblyopic," *i. e.*, practically useless so far as sight is concerned. Strabismus may be either *convergent* or *divergent*, according as the eye squints inward or outward.

The *treatment* of strabismus aims to correct the defect either by lenses or by operation. A tendency to strabismus in children is often overcome by obliging them to wear proper glasses. Periodic squint is particularly amenable to such treatment. The eye which habitually fixes may be bandaged for a half-hour two or three times a day, so as to force the squinting eye to fix and in this way to retain its visual acuity.

For remarks on operative treatment, see Chapter xii.

**III. Paralysis.**

If a muscle or set of muscles be affected so that all function is suspended, the condition is true paralysis; but if the function be only impaired, the condition is called paresis.

The diagnostic point of difference between concomitant and paralytic strabismus consists, as has already been said, in the fact that primary and secondary deviation are not equal to each other. In paralytic strabismus secondary

deviation is greater than primary. Suppose the right externus to be paralyzed and the eye to squint inward. When the left eye is covered and the right eye attempts to fix, a very strong impulse is sent by the brain to the paralyzed right externus and the muscle is unable to respond. At the same time a correspondingly strong impulse is sent to the left internus, and contraction of this healthy muscle throws the left eye markedly inward. Thus the secondary deviation is observed to be greater in extent than the primary deviation, and this can be demonstrated by linear measurement. "Ophthalmoplegia externa" is that condition in which all the external muscles of the eye (*i. e.*, the four straight muscles and the two oblique) are paralyzed. "Ophthalmoplegia interna" signifies the condition in which the internal muscles (*i. e.*, the ciliary muscle and the sphincter pupillæ) are paralyzed. "Ophthalmoplegia totalis" signifies paralysis of all the ocular muscles. "Conjugate" paralyses depend upon disturbance of the association centers. These centers are of higher rank than those of the nerve-origins and are said to control such movements of the eyes as are mutually dependent,—for example, the movement of both eyes to the right.

*Etiology.*—The predisposing causes of ocular paralysis are often traceable to a diathesis or to the toxic influence of some infectious disease; but the exciting cause (*i. e.*, the actual lesion) is always either intracranial or intraorbital. The lesion may be a primary affection in the nerves themselves, or may be an inflammation or a form of degeneration in the area of the brain substance where the nerves originate. Vascular disturbances (as atheroma, aneurysm, occlusion) may cause paralysis by pressure, or may interfere with nutrition to such an extent as to impair function. Paralysis dependent upon rheumatism is very frequent. Syphilis,

tuberculosis, tabes, diabetes, toxemia, disseminated sclerosis, and other diseases are also responsible for many cases of ocular paralysis; while of the infectious diseases diphtheria is the most frequent cause. These diseases either directly affect the sheaths of the nerves or give rise to neoplasms, hemorrhages, or other disturbances in the region of the nuclei or of the tracts.

*Course* and *Prognosis.*—The development of paralysis may be either sudden or gradual. The course is always more or less chronic. Even in the most favorable cases, six weeks or more are required for a cure, and many paralyses are absolutely incurable. In cases of long standing, atrophy of the muscle may occur. The prognosis in each case depends entirely upon the cause, and upon the length of time that has elapsed before beginning appropriate treatment. As a rule, a favorable prognosis may be given when ocular paralysis is a symptom of beginning locomotor ataxia; for as the disease progresses the paralysis is likely to disappear. Paralysis of the external rectus is often seen in the old, chiefly between the ages of sixty and seventy. It often disappears in the course of a few months, leaving no apparent trace of disturbance of the nervous system.

*The Symptoms* are :—

A. Subjective.
   (*a*) Diplopia.
   (*b*) Vertigo; nausea; headache.
   (*c*) False orientation.

B. Objective.
   (*a*) Limitation of movement.
   (*b*) Oblique position of head.

Diplopia, or double vision, occurs when the patient looks at an object situated within the sphere of action of the

paralyzed muscle. For example, if the right externus be paralyzed, and the patient be required to hold the head straight, and turn the eyes so as to perceive an object situated upon his right, rays from the object will enter the unaffected eye and will be focused at the macula; while similar rays entering the paralyzed eye will fall upon the retina at the nasal side of the macula. Two images of the object will thus be formed, the one clear, the other dim. A study of the relative positions of these images is a reliable method of determining which muscle, or set of muscles, is paralyzed. The patient should be required to hold the head straight, and to follow with his eyes the movements of a pencil held in the physician's hand. The moment he perceives two images of the pencil he should make it known. Now, by covering one eye and asking which image disappears, homonymous or heteronymous diplopia can be diagnosticated. If one image be erect, while the other is inclined toward it, or away from it, there is involvement of some one or more of the superior or inferior muscles, or of the obliques. Take, as an example, a paralysis of the superior rectus of the right eye. On the patient's looking up, diplopia occurs, and the vertical distance between the images increases as the patient looks farther upward. The position of the false, dim image is on the right side and it is oblique, its upper part being inclined away from the erect, true image. In adduction of the eyes, this obliquity increases. These phenomena are explained by the fact that the superior rectus is an elevator, a rotator, and an adductor. The double images produced in each variety of paralysis can be studied in this way.

Vertigo is a result of diplopia and of the inability to correctly locate objects. This variety of vertigo is called "visual vertigo," because it disappears when the paralyzed

eye is covered. Nausea is frequently present, and is felt especially on going up and down stairs. Patients usually complain of severe headache.

False orientation signifies the patient's inability to correctly locate objects. If requested to touch with his finger a given object, he forms an incorrect judgment as to the location of the object, and places his finger too far to the right or to the left, or too far up or down, according to the variety of diplopia present. The gait of a patient with ocular paralysis is uncertain.

Limitation of movement is a natural consequence of disordered muscular function. In most cases this limitation can be appreciated on requiring the patient to hold his head still, and to follow with his eyes the movements of the physician's finger as it is carried in various directions. But in paralysis too slight to be detected by this test, the diagnosis must be made from a study of the relative positions of the double images.

The oblique position of the head is significant. The patient learns to control his diplopia by keeping his head turned towards the side of the affected muscle. By this means the demands upon the muscle are less frequent. There is a characteristic position of the head for each form of paralysis.

*Treatment* should be directed to

1. Removal of the cause.
2. Relief of symptoms.

Syphilis and rheumatism yield most satisfactorily to treatment. Cases of the former disease should receive vigorous anti-syphilitic medication. Paralyses of rheumatic origin are controlled by the salicylates or by colchicum, combined with diaphoresis and with regulation of daily life. Small, continued doses of bichlorid of mercury are recom-

mended in cases due to slight degenerative changes. General tonic treatment should not be overlooked.

During the long period through which the patient must pass before improvement occurs, the distressing subjective symptoms can be relieved by excluding the affected eye from all part in visual perception. This may be accomplished by the use of an opaque disk, or by the Liebreich patch, which serves very well and can be easily made. It is simply a half circle of black cloth, lined with white or green, and having a long piece of tape sewed on at each angle. The patch having been placed before the eye, the tapes are carried to the back of the head, crossed, then brought to the forehead and tied.

Cases in whom cure is entirely impossible, and in whom strabismus has developed, can be operated upon for the sake of removing the disfigurement caused by the deviation of one eye. This is the only indication for operation upon an eye affected by paralysis.

## CHAPTER VII.

### DISEASES OF THE CONJUNCTIVA, LIDS, AND LACRYMAL APPARATUS.

#### I. THE CONJUNCTIVA.

The "conjunctival sac" is divisible into three portions :—

(*a*) The tarsal.

(*b*) The bulbar.

(*c*) That of the fornix.

The *tarsal conjunctiva* (also called the palpebral, because it lines the lids) covers the tarsal cartilage. It is so thin that the glands lying underneath it can be seen when no hyperemia or swelling of the conjunctiva is present. It is very vascular.

The *bulbar conjunctiva* covers the anterior part of the eyeball, including the cornea. In comparison with the other two divisions of the conjunctiva, this portion is only slightly vascular.

The *conjunctiva of the fornix* serves to connect the tarsal with the bulbar conjunctiva. It is not so tense nor so intimately connected with its underlying structures as are the other two divisions of the conjunctiva, but is lax in character, and for this reason is sometimes spoken of as "the folds of transition." This laxity, together with its abundant blood supply, admit of extensive swelling even under slight provocation. Trachoma granules are most liable to occur in the folds of transition.

The "plica semilunaris" is a fold of tissue found at the inner corner (or "canthus") of the eye. It is an abortive

remnant of the *palpebra tertia* in animals. The "caruncle" is also found at the inner canthus, and is in reality a small island of skin (hairs, sweat and sebaceous glands, etc., being found in it).

The conjunctiva is supplied with blood from the ciliary arteries. The posterior ciliary branches supply the conjunctiva of the lids and of the fornix, but the vessels of the bulbar conjunctiva are derived from the anterior ciliary branches. There being, then, two systems of blood-supply for the conjunctiva, we speak of "ciliary injection" and of "conjunctival injection." The former accompanies most diseases of the cornea, iris, and ciliary body. Conjunctival injection is superficial.

**Acute Catarrhal Conjunctivitis.**

*Etiology.*—(*a*) Contagion.
(*b*) Atmospheric influences.
(*c*) Contiguity of tissue.
(*d*) Traumatism.

*Course.*—The disease usually lasts from eight to fourteen days. It may disappear spontaneously, or it may run into a chronic form. The acute form gives the patient much more annoyance than does the chronic form. Usually both eyes are affected, either simultaneously or one about a week after the other. Conjunctivitis is often caused by throat and nasal affections. The presence of a foreign body in the conjunctival sac or actual injury of the membrane is likely to produce violent acute conjunctivitis.

*Symptoms.*

A. Subjective.
(*a*) Increased lacrymation.
(*b*) Photophobia.
(*c*) Burning and itching.

If there be pain, there are probably complications which

involve the cornea. The sensation of sand in the eyes is produced by flakes of mucus which are swept over the sensitive cornea by the movements of the lids. These flakes often temporarily obscure vision. All subjective symptoms reach their climax as night approaches.

B. Objective.

(*a*) Redness, relaxation, and swelling.

(*b*) Increased secretion (either with or without alteration in its character).

The congestion is usually "reticulate," *i. e.*, the vessels can be distinguished from one another. The symptoms are confined either entirely, or almost entirely, to the conjunctiva of the tarsi and of the fornici. In the severe form known as "Ophthalmia Catarrhalis" the whole conjunctival sac is involved.

*Treatment.*

The three objects of treatment are :—

(*a*) To remove the cause.

(*b*) To abort or to control the attack.

(*c*) To prevent the sequence of the chronic form.

*The Use of Silver Nitrate Solution.*—The strength of the solution usually recommended is one per cent. (*i. e.*, gr. v–f℥j). Its application should be preceded by thorough washing of the conjunctival sac with boracic acid solution (gr. x–f℥j). Absorbent cotton, wound upon an applicator, having been dipped into the silver solution, and care having been taken to remove from the swab any excess of the liquid, the lids are everted and touched. The manner of application is of even more importance than the strength of the solution.

"If the eye be thoroughly cleansed and a ten-grains solution be passed lightly over the surface two or three times by a cotton swab freshly charged each time, the effect

of a twenty or thirty-grains solution, as ordinarily applied, will be readily attained. On the other hand, if the brush be but moderately charged and passed lightly and rapidly over, and instantly followed by the free application of salt water, a very moderate effect will result." *

The immediate result of an application to a hyperemic lid is *exacerbation of symptoms*. A slough forms, which as a rule begins to separate in the course of half an hour and is thrown off in shreds. There is then paleness of the surface, and the *stage of remission* occurs. This lasts a day, perhaps, and is followed by the *stage of recrudescence*. The occurrence of this latter stage is the signal for a fresh application of silver. One should be careful not to make a severe application, unless such be especially indicated; for too deep penetration will but increase the inflammation. An application of silver causes the upper epithelium to die. The inflammatory exudate which is present in the tissues underneath is thus encouraged to escape, and the tissues are relieved. Silver should not be applied at night, for, the discharge of exudate having been induced, the secretion fails to escape during sleep, lies in the conjunctival sac, and dries upon the margins of the lids, so that new sources of trouble are introduced. If applications of silver are too long continued, "argyria," permanent staining of the tissues, may be caused.

Upon subsidence of acute inflammatory symptoms, non-irritating collyria should be used. One commonly employed is:—

℞. Sodii boratis, . . . . . gr. iv.
Ac. boracici, . . . . . gr. x.
Aq. destill., . . . . . f℥j.
M. Sig.—Use freely three times a day.

* "Diseases of the Eye," Norris and Oliver.

Solutions of lead are to be avoided in cases in which there is an abrasion of the cornea, as "lead incrustation" with ugly opacities may be induced. Peroxid of hydrogen (25 per cent. solution) is used in a manner similar to that described for silver nitrate. The application is more painful than that of silver.

*Complications.*—(*a*) Corneal ulcers.
(*b*) Iritis.

It is only necessary to recall that the conjunctiva takes part in forming the anterior covering of the cornea to understand how a neglected conjunctivitis may in time involve the cornea and produce solution of continuity. Iritis accompanies only the severe forms of catarrhal conjunctivitis; it may occur in consequence of an ulcer of the cornea.

**Chronic Catarrhal Conjunctivitis.**

*Etiology.*—(*a*) Acute catarrhal conjunctivitis.
(*b*) Bad air; bad hygiene.
(*c*) Occupation.
(*d*) Ametropia.
(*e*) Contiguity of tissue.

*Course.*—The chronic form of conjunctival catarrh usually persists for a long time, variable in accordance with the severity of the disease and with the circumstances under which the patient lives. Senile chronic catarrh of the conjunctiva is common. Its chief danger lies in the possible complications to which it may give rise.

*Symptoms.*—These are generally the same as in the acute variety, but of far less aggravated type. Dryness of the conjunctiva, instead of increased secretion, may occur. This form is known as "catarrhalis sicca." The subjective symptoms are often not commensurate with the objective changes.

*Treatment.*—The objects of treatment are :—

(*a*) To remove the cause.

(*b*) To control the disease.

If there is abundant secretion and relaxation, silver nitrate solution may be used as in the acute form. If the inflammation be of the type which might be designated as *sthenic*, soothing collyria should be used. For the annoying symptom of tendency on the part of the lids to adhere to each other, an ointment may be used, made as follows :—

℞. Hydrarg. ox. flav., . . . . . gr. j.
Petrolati, . . . . . ʒ j.
M. Sig.—Apply at night.

A small piece of this ointment should be placed on the inner surface of the lower lid. The eye should then be closed, and the lids thoroughly rubbed over the surface of the globe until the salve is well distributed through the conjunctival sac.

*Sequelæ.*—(*a*) Blepharitis marginalis.

(*b*) Eczema of lids.

(*c*) Ectropion.

**Follicular Conjunctivitis.**

*Etiology.*—This is not as yet well known. Contagion and miasm seem prominent causes. The disease may accompany acute or chronic catarrhal conjunctivitis. It occurs most frequently in youth.

*Course.*—The course is likely to be protracted.

*Symptoms.*—

A. Subjective.

Those of acute or chronic conjunctivitis.

B. Objective.

(*a*) Those of acute or chronic conjunctivitis.

(*b*) Presence of enlarged follicles.

The presence of distended follicles characterizes this form

of conjunctivitis. They are seen as small granules about the size of a pin's head, and they lie in the folds of transition. They consist of circumscribed adenoid tissue, and in this respect are like trachoma granules. Trachoma, however, causes permanent destructive changes in the conjunctiva, whereas the follicles in follicular catarrh disappear, leaving no trace.

*Treatment.*—Fuchs recommends the use of lead ointment (1–5) when no corneal ulcers are present. The hygienic surroundings should be improved if possible. Fresh air and good diet are of great importance.

**Trachoma** (*Conjunctivitis Trachomatosa*).

*Etiology.*—The disease is always the result of infection directly through the medium of the conjunctival secretion.

*Course.*—There is a constantly increasing hypertrophy of tissue, followed ultimately by cicatrization. Contraction takes place at the folds of transition, and various complications may follow. Trachoma is a very protracted disease, lasting often many months and even years.

*Symptoms.*—

A. Subjective.
   (*a*) Pain (in severe forms).
   (*b*) Symptoms of catarrhal conjunctivitis.

B. Objective.
   (*a*) Presence of sago-like bodies.
   (*b*) Hypertrophy.
   (*c*) General symptoms of catarrhal conjunctivitis.

*Treatment.*—The objects are :—

   (*a*) To check the inflammation.
   (*b*) To prevent hypertrophy.

The best treatment for trachoma is the application of the solid blue-stick (copper sulphate). This application is very

irritating and very painful. It is the best agent with which to combat hypertrophy. Silver is better borne, but is not so effective. Cleansing of the conjunctiva should be regular and frequent. Hygiene should always be considered and re-infection avoided. (For description of operative treatment see Chapter xii.)

*Complications.*—(*a*) Pannus.

This is a deposition beneath the epithelium of the cornea of a tough, new tissue containing vessels. It creeps across the cornea, and may ultimately cover the entire cornea like a cloth, from which similarity it derives its name.

(*b*) Ulcers.

These may occur in the cornea with or without the accompaniment of pannus. They rarely occur within the area occupied by pannus.

*Sequelæ.*—(*a*) Distortion of lids and misplacement of lashes.

Changes in the shape of the tarsus are induced by the process of cicatrization, and these changes cause the lashes to turn inward so as to irritate the cornea. This condition is called *trichiasis*. Ectropion (eversion of the lid) results from swelling of the conjunctiva. Contraction of the tarsus completes the eversion.

(*b*) Symblepharon. (See page 95.)

(*c*) Corneal opacities.

These are the inevitable result of ulcers which have penetrated beneath the epithelium. Bowman's membrane is never replaced except by cicatricial tissue.

(*d*) Xerosis.

This is dryness of the cornea due to absence of conjunctival fluid. It is one of the worst and most distressing after-effects of trachoma.

(*e*) Anterior Staphyloma.

This usually is the result of pannus. The cornea, having become softened, gives way before intraocular pressure. Staphyloma is ocular hernia.

*The Differential Diagnosis of Trachoma.*—This is not easily made. The disease which trachoma closely resembles is follicular conjunctivitis. In follicular conjunctivitis the bead-like bodies are liable to be arranged in rows, like strings of pearls. The trachoma granules have no regularity of arrangement. Trachoma bodies are likely to be larger and less sharply defined in outline than the enlarged follicles. Often an inquiry into the history of the case will serve to make the diagnosis reliable.

**Phlyctenular Conjunctivitis.**

*Etiology.*—(*a*) Scrofulous diathesis.
(*b*) Bad hygiene.
(*c*) Debilitating diseases.

*Course.*—An uncomplicated attack lasts from eight to fourteen days.

*Symptoms.*—

A. Subjective.
(*a*) Photophobia.
(*b*) Blepharo-spasm.
(*c*) General symptoms of acute catarrhal conjunctivitis.

B. Objective.
(*a*) Presence of phlyctenule.
(*b*) Increased lacrymation.
(*c*) Moderate amount of discharge.

At the beginning of a typical attack, an inflamed area of the ocular conjunctiva is discovered, triangular in shape, its apex at or near the corneal limbus. At the apex is a small conical swelling. The epithelium at the summit of this cone soon begins to break down, and the tissue underneath

undergoes the same process. Thus an ulcer is formed which, if all goes well, gradually sinks to the level of the conjunctiva, becomes clean, and is again covered by epithelium. Phlyctenules may occur anywhere in the conjunctiva and upon the cornea. They are rarely observed upon the tarsal conjunctiva.

*Treatment.*—Daily applications of glycerite of tannin (1–20) are very effective. A somewhat large swab should be made and a generous amount of the medicine carried into the conjunctival sac. This treatment should be combined with the use every night of yellow oxid of mercury ointment in the manner described on page 85.

The hygiene of the patient is of more importance than medical treatment. Half-fed children with phlyctenular conjunctivitis are often entirely cured by a few days in the country and by proper diet, without any local treatment whatever. Tea and coffee should be prohibited, and regular habits of life advised.

**Ophthalmia Neonatorum** (*Conjunctivitis Gonorrhoica*).

*Etiology.*—The gonorrheal cocci are always to be found in the ocular secretion of patients suffering from this variety of ophthalmia, and they constitute the direct cause of the disease.

*Course.*—In infants, the disease manifests itself usually within three days after birth, and the climax is not reached until two or three days later. The four stages of the disease are :—

(*a*) Stage of incubation (two to three days).
(*b*) Stage of infiltration (three days).
(*c*) Stage of pyorrhea (variable, usually at least six weeks).
(*d*) Stage of chronic blennorrhea (variable, usually at least three months).

*Symptoms.*—

A. Subjective.
   (*a*) Pain.
   (*b*) Symptoms of severe conjunctivitis.

B. Objective.
   (*a*) Swelling of lids.
   (*b*) Intense inflammation of conjunctiva.
   (*c*) Chemosis.
   (*d*) Discharge.

There is intense edema of the lids, so that it is almost impossible to open them sufficiently to examine the cornea. The conjunctiva is tense and of granular appearance in the early stage of the disease, and there is a rigid wall of swelling (chemosis) around the margin of the cornea. Later, a secretion resembling meat-juice (because of admixture of blood) escapes from the eye. This discharge rapidly becomes purulent. With the onset of the stage of pyorrhea, the lids become less edematous. Slight fever is usually present, and the lymphatic gland in front of the ear on the side of the affected eye is likely to swell.

*Treatment.*—Prophylaxis and cleanliness meet almost all the indications for treatment. The occurrence of the disease can often be prevented by the use of Credé's method of prophylaxis. Immediately after birth the eyes of the new-born should be thoroughly cleansed with boracic acid solution, after which two or three drops of silver nitrate solution (one per cent. or two per cent.) should be instilled into each conjunctival sac. The silver nitrate cauterizes the epithelium and destroys the gonococci before they have penetrated deeply into the tissues. In case one eye becomes affected by the disease, the unaffected eye should be bandaged. The edema and pain are relieved by iced compresses. These symptoms in the adult are modified by leeching. As

soon as discharge becomes apparent and the conjunctiva softens, silver nitrate solution should be applied on a swab as for acute conjunctivitis, and this treatment should be continued until all inflammation of the conjunctiva has disappeared. Throughout the course of the disease, frequent and thorough cleansing of the conjunctival sac forms an important part of the treatment. For this purpose, bichlorid of mercury solution is often employed (1–4000), but the ordinary boracic acid solution answers the purpose fully as well. Complications should be treated in accordance with their nature.

*Complications.*—Involvement of the cornea is most to be dreaded. In severe cases the cornea may become cloudy as early as the second or third day of the disease. Foci of infiltration form, which tend to break down and become ulcers. Annular abscess may occur.

The prognosis of each case depends upon the degree to which the cornea becomes affected. If perforation of the cornea occurs, incarceration of the iris will follow, and total blindness may result.

Ophthalmia gonorrhoica may occur in the adult as well as in the new-born. The disease in the adult is, as a rule, much more virulent and destructive than in the child.

**Injuries of the Conjunctiva.**

1. *Foreign bodies in the conjunctival sac* frequently lodge on the under surface of the upper lid, and they tend also to lodge in the folds of transition. If not removed they excite acute catarrhal conjunctivitis. If a foreign body lodges in the epithelial layer of the cornea it should be removed as soon as possible, otherwise the development of a corneal ulcer may result.

2. *Burns by caustics* are treated by copious instillations of neutralizing solutions. Burns by caustic alkalies may be

treated by washing the sac with milk. In burns by lime the sac should be first washed with oil, then a drop of concentrated solution of sugar should be instilled. This forms an insoluble compound with lime. The after-treatment of such cases is directed towards the control of inflammation. Atropin may be used to assist in suspending the functions of the eye. Cold compresses relieve pain. The prevention of adhesions should be accomplished if possible, although the prognosis of success in this direction is grave.

*3. Ecchymosis of the conjunctiva* may be the result of traumatism, or it may follow violent coughing; frequently it occurs without any apparent cause. Its appearance is often startling to the patient, but one can confidently promise recovery within a few days or weeks. As a rule, no treatment is necessary beyond cleansing of the conjunctival sac.

**Pterygium.**

A pterygium is composed of a fold of mucous membrane extending from the conjunctiva to the cornea. Usually, a pterygium is found at either the inner or outer side of the cornea, since this part of the conjunctiva corresponds in situation to the palpebral fissure and is, therefore, more exposed to outside influences than any other part of the conjunctiva. A pterygium invades the cornea. Its apex lies in the cornea and is immovably attached to it. The pterygium may progress to the center of the cornea. Its presence affects vision, not only because of encroachment upon the pupillary area, but also because of the irregular astigmatism which it causes. A pterygium originates in a pinguecula, but the presence of a pinguecula does not argue the ultimate development of a pterygium. This affection is seen most often in elderly people. Its treatment is operative (see Chapter xii); but interference is not justifiable before the growth has begun to invade the cornea.

## II. THE LIDS.

The skin surface of the lids is subject to the same general diseases which attack the skin in other situations of the body; for example, herpes zoster, eczema, erysipelas, abscess. Ecchymoses and edema are especially liable to form in the lids because of the loose connective tissue found in these structures. The tarsus (called by Fuchs the "skeleton" of the lid) gives firmness to the lid. In everting a lid, one should be sure to place the finger-tip behind the tarsal cartilage, otherwise several ineffectual attempts will be made before the lid is turned. Another practical suggestion is that the patient be told to look downward while the lid is being everted.

The Meibomian glands lie imbedded in the tarsus. They are arranged regularly, parallel to one another, and run from the posterior to the anterior border of the tarsus. In a healthy eye, they can be seen through the transparent conjunctiva. They are large, sebaceous glands, and their office is that of lubrication.

**A Hordeolum** (*stye*) is an abscess originating in one of the glands (known as Zeiss' glands) which empty into the hair follicles. All the usual symptoms of abscess are present. The course of a hordeolum is from three to four days. The treatment consists in the application of hot-water compresses, and in the evacuation of the pus as soon as yellow discoloration of the surface is noticed.

**A Chalazion** is the result of obstruction of a Meibomian gland. There may or may not be inflammatory symptoms. Usually, the course is chronic and unattended by pain. The imprisoned sebaceous material may break down into pus. The swelling caused by the obstruction is likely to increase until disfigurement is occasioned. Palpation shows the

tumor to be intimately connected with the tarsus. On everting the lid, a depressed and discolored spot is found. It is at this point that an incision should be made in evacuating a chalazion. The distinguishing features in hordeolum and chalazion are as follows :—

*Hordeolum.*—Course, acute ; symptoms, inflammatory ; situation, margin of lid.

*Chalazion.*—Course, chronic ; symptoms, non-inflammatory ; situation, a Meibomian gland.

**Trichiasis** is that condition in which the lashes are directed backward and inward, so as to irritate the cornea. This condition may be confined to only a few cilia, or it may extend to all. In consequence of constant irritation, the cornea becomes more or less seriously affected. Trachoma, because of the inevitable cicatrices which it produces, is the most frequent cause of trichiasis.

**Distichiasis** is a modified variety of trichiasis. It is the condition in which one row of cilia is directed backward while another is directed normally forward.

The *treatment* of these conditions is either removal of the offending cilia one by one (epilation), or permanent destruction of the cilia follicles by electrolysis or by ablation. Operations upon the lids may be done to change the direction of the lashes. (See Chapter xii.)

**Entropion** is that condition in which the lid is turned inward. It often develops in old people whose lids are flabby and covered by distensible skin. It is often a sequel of trachoma. It may follow any diseases or injuries which serve to change the shape of the tarsus or to form cicatrices in the skin.

**Ectropion** is that condition in which the lid turns outwards. It may result from causes similar to those of entropion, and also from paralysis of the orbicularis palpebra-

rum. The condition in which the lid, even when closed as tight as possible, fails to cover the eye, is called *lagophthalmus.*

*Treatment* of entropion and ectropion may be either operative (see Chapter xii) or palliative. Suitable precautions should be taken to keep the cornea moistened and protected, so far as possible, from injury.

By **Symblepharon** is meant adhesion of the lid to the eyeball. Adhesion of the lids to each other at the external canthus is known as *blepharo-phimosis.* These conditions are produced by chronic conjunctival inflammation or by injuries. The treatment is operative. (See Chapter xii.)

**Blepharospasm** is a condition produced by spasmodic contraction of the orbicularis muscle. It may be a symptom of some ocular trouble, or it may be essential in character. It is frequently of hysterical origin.

**Ptosis** is that condition in which the power to elevate the lid is lost. Ptosis may be either partial or complete. Except the condition be congenital, it is due to paralysis.

**Epicanthus** is that condition in which a fold of skin stretches from either side of the nose to the brow. A moderate amount of epicanthus is observed in the Mongolian people. A slight degree may disappear as growth is attained. If there is sufficient epicanthus to produce actual disfigurement, operation should be advised. (See Chapter xii.)

**Marginal Blepharitis.** This disease may be defined as a chronic inflammation of the margins of the lids. The inflammation may be of the squamous or of the ulcerative type.

*Etiology.*—The constant forerunner of marginal blepharitis is chronic conjunctivitis, which in turn is dependent upon a variety of causes.

*Course.*—It is always chronic, sometimes enduring

throughout life. The ulcerative type may produce destruction of the cilia follicles.

*Symptoms.*—

A. Subjective.

All the symptoms of chronic catarrhal conjunctivitis are present.

B. Objective.

(*a*) Crusts at bases of cilia.

(*b*) Scanty and misplaced cilia.

(*c*) Reddened and hypertrophied margins of lids.

(*d*) Glueing of lids during sleep.

(*e*) General signs of chronic conjunctivitis.

*Treatment.*—This is directed to—

(*a*) Removal of cause.

(*b*) Relief of symptoms.

An error of refraction often is the cause of chronic conjunctivitis and marginal blepharitis, and in such cases the disease can be permanently cured by wearing the proper lenses. The use of yellow oxid of mercury ointment (gr. j to ʒj) is very effective. An application each night will prevent adhesion of the lids in the morning, and will also facilitate the removal of crusts. A collyrium should be used three or four times during the day. In the ulcerative type, each separate ulcer should receive treatment, and the cilia which project from it should be removed. Each ulcer may be touched with the solid stick of silver nitrate to hasten healing.

*Sequelæ.*—Trichiasis, hypertrophy, ectropion, epiphora.

### III. THE LACRYMAL APPARATUS.

#### Blennorrhea of the Lacrymal Sac.

By this term is meant a distention of the sac caused by accumulation of material within it.

*Etiology.*—The disease is always due to stricture of the lacrymal duct. This stricture is due, in turn, to nasal affections.

*Course.*—Almost always chronic.

*Symptoms.*—

A. Subjective.

(*a*) Epiphora (tears running over the cheeks).

(*b*) Pain.

B. Objective.

(*a*) Regurgitation from the puncta.

(*b*) Swelling in the situation of the lacrymal sac, with other signs of inflammation.

*Treatment.*—Treatment should be directed towards—

(*a*) Correction of the cause.

(*b*) Evacuation of the sac.

(*c*) Relief of symptoms.

Since the cause is traceable to nasal disease, the nose and throat should receive especial attention. The patient may be directed to frequently empty the sac by pressing upon it with the finger. The lacrymal passages should be cleansed by syringing with boracic acid solution. Conjunctivitis and any other complications should receive appropriate treatment.

Dilatation of the obstructed duct is effected by means of graduated sounds. Slitting of the canaliculus is comparatively seldom done. The only advantage to be gained is facility for the introduction of sounds, whereas the permanent effects are often a source of great discomfort to the patient. In certain extreme cases, however, it is a perfectly justifiable procedure.

Destruction of the lacrymal sac is indicated only in such cases as are not relieved by treatment with sounds. Destruction of the sac (performed either by extirpation or

by obliteration) is followed by epiphora, but this annoyance may, in some cases, be preferable to that of a constantly suppurating cavity. (For description of operations, see Chapter xii.)

**Dacryo-cystitis.**

By this term is meant a suppurative inflammation of the tissue bordering upon the lacrymal sac. It is nothing more or less than the formation of an abscess, which ruptures externally and establishes a fistulous communication between the lacrymal sac and the external surface.

*Etiology.*—It is the result of blennorrhea; very rarely is it due to any other cause.

*Symptoms.*—Those of abscess elsewhere in the body, as redness, pain, and swelling.

*Treatment.*—This is directed towards—

(*a*) The prevention of abscess, if possible.

(*b*) The hastening of an inevitable abscess.

(*c*) Evacuation of the abscess.

(*d*) Care of the fistula.

An abscess may be aborted by evacuation and cleansing of the lacrymal sac. A pressure bandage is often useful. An abscess which cannot be aborted should be treated with warm, moist compresses, and at the proper time an incision should be made at the point where the presence of pus is most evident.

A lacrymal fistula having been produced, it should be kept open by strips of iodoform gauze, and should be cleansed frequently. Since blennorrhea of the sac has preceded the formation of abscess, the fistula must not be allowed to close until after the causal disturbance has subsided. In incurable cases, destruction of the sac is practiced.

## CHAPTER VIII.

### DISEASES OF THE CORNEA, IRIS, AND CILIARY BODY.

#### I. THE CORNEA.

The vertical diameter of the cornea is 11 mm., the horizontal is 12 mm. The cornea is thinner at its center than at its edge. The layers of the sclera slightly overlap those of the cornea anteriorly. The healthy cornea is transparent and is destitute of blood-vessels. Its principal layers are :—

1. Anterior epithelium.

2. Bowman's membrane.

There is a distinct line of separation between this membrane and the anterior epithelial layers, but there is intimate connection between it and the underlying lamellæ of the cornea.

3. Stroma.

This is composed of ground substance, cells, and connective tissue. Lymph spaces are present, connected by minute canals. Loops of blood-vessels at the corneal margin (limbus) are derived from the anterior ciliary arteries. The blood-plasma passes from these loops into the lymph passages of the cornea, and in this way the tissue is nourished.

4. Descemet's membrane.

The distinctive features of this membrane are its power of resisting the action of chemical agents and pathological processes, and its opposition to the filtration of liquids.

5. Posterior endothelium.

The cornea is continuous at its margin with three other

ocular tissues, the conjunctiva, the sclera, and the uvea (iris, ciliary body, and choroid). Diseases which affect the conjunctiva are likely to involve the conjunctival part of the cornea; while diseases of the uvea are likely to affect the deeper layers of the cornea. The cornea is richly supplied with nerves. Diseases affecting the anterior part of the cornea are especially painful.

**Ulcer of the Cornea.**

*Etiology.*—An ulcer originating in the cornea itself (primary ulcer) is most often the result of traumatism. An ulcer developing in consequence of disease of other parts of the eye (as, for example, the conjunctiva) is called secondary. Ulcers are often an evidence of impaired nutrition or of constitutional disease. When a phlyctenule occurs on the cornea, it breaks down and forms an ulcer. The affection is often called "phlyctenular keratitis."

*Course.*—Disturbance of the epithelium is necessary to the formation of an ulcer. The first sign of a focus of inflammation of the cornea is a cloudy spot caused by infiltration. The epithelium becomes involved and is exfoliated. Then the corneal tissue breaks down progressively. An unhealthy ulcer of the cornea presents the same general appearances as an ulcer of any other part of the body. Its base is gray and uneven, its edges cloudy and perhaps undermined. An ulcer which progresses most rapidly at its base is likely to cause perforation of the cornea, while one which progresses most rapidly at the sides leaves a large opacity. A regressive ulcer becomes healthy by throwing off dead tissue, and by the resorption of exudate. Its base becomes smooth and its edges less opaque. At this stage minute vessels develop, originating in the marginal loops, and run to the ulcer. Their office is to supply material for regeneration; their appearance, therefore, is a

sign of beginning cicatrization. The newly-formed tissue is not corneal, but connective. Bowman's membrane is never replaced except by fibrous tissue; hence an ulcer which involves other layers in addition to the epithelial causes more or less opacity.

*Symptoms.*—

A. Subjective.

(*a*) Pain.

(*b*) Photophobia.

(*c*) Increased lacrymation.

B. Objective.

(*a*) Pericorneal zone.

(*b*) Hyperemia or inflammation of iris (often).

(*c*) Presence of ulcer.

*Complications.*—

(*a*) Perforation.

The patient appreciates this occurrence by sudden pain in the eye and the escape of liquid, the aqueous humor. The anterior chamber being now obliterated, the iris and lens lie against the cornea, and adhesions (synechiæ) are inevitable.

It depends upon the relative position of the ulcer and the iris as to whether the latter prolapses or not. In case the iris is caught in the wound and remains there during the process of healing, the white opacity which forms, and in which the iris is incorporated, is called an *adherent leukoma*. If the area of perforation is small, the iris may be dragged away from the wound by the action of atropin or of eserin, after the anterior chamber has been re-established. If the area of perforation is large, the iris is swept into the wound and bulges forward, forming an anterior staphyloma which has a tendency to become larger. Adhesion of the cornea to the anterior capsule of the lens causes anterior polar cataract.

(*b*) Luxation of the Lens.

When perforation occurs, the suspensory ligament of the lens may rupture and allow the lens to assume an oblique position, or even to escape from the eye.

(*c*) Purulent Irido-cyclitis; panophthalmitis.

Either of these complications may occur from infection of structures adjacent to the cornea. (See page 118.)

*Treatment.*—This varies in accordance with the stage of the ulcer.

(*a*) Progressive Ulcer.

Consider first the cause. If it is local, as, for instance, a cilium turned inward and irritating the cornea, it should be removed; if constitutional, appropriate medicine should be given. Atropin sets the iris at rest, and (if the ulcer is central) removes it from the site of a possible perforation. Immobilization of the lids can be accomplished by the use of a bandage. In case a bandage is not used, dark glasses should be worn. Iodoform dusted into the eye serves well as a disinfectant. Hot compresses applied at intervals will relieve pain. Frequent cleansing of the conjunctival sac is necessary. No irritants should be used at this stage unless the ulcer be foul. A foul ulcer should be cleansed by scraping with a corneal spud, cauterizing the base, and washing with a disinfectant solution. If perforation threatens, the patient should be kept as quiet as possible, and a mydriatic or a myotic should be used to combat adhesion of the iris, in accordance with the situation of the ulcer. It is only in the most favorable cases of perforation that adherent leukoma can be prevented. Paracentesis of the cornea may prevent perforation. (See Chapter xii.)

(*b*) Regressive Ulcer.

Treatment should be directed to the rapid healing of the ulcer, and to the formation of as small and as slight an opa-

city as possible. Irritants should be used in this stage, such as yellow oxid of mercury ointment. Opacities tend to slowly grow clearer, but a prognosis in regard to this depends upon the age of the patient and upon the extent of the involvement of the corneal tissue. Tattooing of the cicatrices often accomplishes very good cosmetic effect. A central cicatrix affects vision very decidedly; a cicatrix in any situation produces irregular astigmatism.

**Abscess of the Cornea.**

This is a circumscribed cavity containing pus and situated in the substance of the cornea.

*Etiology.*—Corneal abscess is due to infection either from without or from within. Infection from without must always occur through a lesion of the corneal epithelium. A foreign body which injures the cornea may infect it at the same time. A chronic purulent secretion of the conjunctival sac or of the lacrymal apparatus may infect the cornea and produce abscess. Infection from within occurs through the medium of the blood, and abscesses thus caused are called *metastatic.*

*Symptoms*, *Course*, and *Prognosis.*—A gray infiltration occurs near the center of the cornea. The surface over the infiltration is dotted and slightly raised. Subsequently the whole cornea becomes dull, owing to exudate deposited upon the posterior surface. Iritis usually develops, and a collection of pus in the anterior chamber (hypopyon) appears in most cases. Pain is severe. The abscess finally becomes a suppurating ulcer. The prognosis is not good; perforation of the cornea is likely to occur, and the opacity resulting from corneal abscess is large and dense.

*Treatment.*—If the cause lies in some constitutional disease, appropriate medicines should be given. In small,

recent abscesses cauterization by means of the actual cautery may be efficient local treatment, but the majority of cases require immediate incision, according to the method employed by Saemisch. (See Chapter xii.) The latter method causes perforation of the cornea and is followed by violent pain which is probably the result of increased hyperemia of the iris.

**Interstitial Keratitis** (*keratitis parenchymatosa*, *uveitis anterior*).

*Etiology*.—Predisposing causes are youth and sex. The disease occurs comparatively seldom in those over twenty years of age. The female sex are more likely to suffer from it than the male. Inherited syphilis is the cause of the majority of cases of interstitial keratitis, although the affection may be induced by scrofula or by general physical depression.

*Course* and *Prognosis*.—The signs of the disease appear first either at the center or at the margin of the cornea. The cornea loses its luster and becomes clouded by infiltrate. Small maculæ appear which become confluent, and at the height of the disease the cornea is very opaque. During the process of infiltration, branches develop from the scleral vessels and traverse the deep layers of the cornea in all directions. The course of interstitial keratitis is invariably chronic. The disease continues to be progressive for a period of six or eight weeks, as a rule, and recovery is very slow. The local symptoms of irritation disappear rapidly, but the cloudiness of the cornea persists for months and even years. Purulent disintegration and formation of ulcers are not encountered in this disease. On the other hand, involvement of the iris and ciliary body is usual. The prognosis as to complete restoration is grave. Most eyes affected by the disease are permanently injured. In

favorable cases, however, no synechiæ form and the cornea itself becomes perfectly transparent again.

*Symptoms.*—

A. Subjective.

(*a*) Pain.

(*b*) Photophobia.

(*c*) Increased lacrymation.

B. Objective.

(*a*) Swelling and redness of conjunctiva.

(*b*) Pericorneal zone.

(*c*) Cloudiness of cornea.

(*d*) Presence of deeply situated vessels.

(*e*) Hyperemia or inflammation of the iris.

(*f*) Diminished tension (usually).

*Treatment.*—When the cause is found to be syphilis, mercury is indicated. The drug may be taken by mouth or may be received through inunctions. The latter method is perhaps to be preferred in cases of adults. Tonics, wholesome food, fresh air, and attention to general hygiene are important factors in treatment.

Locally, pain is relieved by the application of hot compresses for five minutes at a time two or three times a day, the compresses being changed about every half minute. Atropin should be instilled in order to set the eye at rest as much as possible and to guard against iritis. Dark glasses should be worn to protect the eyes from light. During the regressive stage, irritants should be employed for the sake of hastening absorption of the exudate. For this purpose the ointment of yellow oxid of mercury (gr. j to ʒj) serves well.

**Injuries of the Cornea.**—Abrasion of the corneal epithelium is a common and painful accident. The chief danger lies in infection of the wound. For this reason the

conjunctival sac should be frequently cleansed and the eye kept closed, or at least protected by dark glasses. If the inflammatory symptoms are severe, it is best to instill atropin. Ulcers frequently form as a result of simple abrasions, but in favorable cases the corneal epithelium is soon regenerated. Wounds which involve more than the epithelial layer produce ulcers or abscesses, and these should receive appropriate treatment.

A foreign body which penetrates the corneal tissue produces results proportionate to the depth of the wound. In case of perforation of the cornea, the lens or iris may also be injured, or the foreign substance may lodge in the structures at the back of the eye. Each case must be treated in accordance with the injury present.

Removal of a foreign substance from the corneal epithelium causes no permanent opacity, provided infection of the wound does not occur. In case the foreign body is not removed by artificial means, it is slowly expelled by the process of suppuration. This process usually gives rise to serious complications. The cornea can be rendered insensitive by the instillation of a few drops of a four per cent. solution of cocain, and the foreign substance can be removed with a corneal spud, or by forceps in case of deep penetration. Cases occur in which foreign bodies remain imbedded in the cornea throughout life, without giving rise to symptoms of irritation.

Injuries by burns and caustics occur in the same manner as those of the conjunctiva (see page 91), and are similarly treated. The nature and the extent of injury of the cornea suggest the treatment required.

## II. THE IRIS.

The healthy iris shows upon its anterior surface numerous radiating striæ which are obscured during hyperemia of the membrane. The substance of the iris is composed largely of blood-vessels supported by loose connective tissue. At its pupillary margin and on its posterior border is found a circular muscle called the sphincter pupillæ. The epithelial layer on the anterior surface of the iris is directly continuous with the endothelial layer of the cornea.

**Iritis.**

*Etiology.*—(*a*) Syphilis.
(*b*) Rheumatism.
(*c*) Scrofula.
(*d*) Diabetes.
(*e*) Fevers and debilitating diseases.
} General.

(*f*) Traumatism.
(*g*) Sympathetic inflammation.
} Local.

*Symptoms.*—Inflammation of the iris without coincident inflammation of the ciliary body is rarely seen, for there is intimate connection between the two structures. There are, however, symptoms which point to special involvement of the iris, and others which show that the ciliary body is chiefly affected. According as one or the other set of symptoms is the more apparent, the affection is called in the one case *iritis* and in the other *cyclitis*, or, in case of combination of the two sets of symptoms, *iridocyclitis*.

A. Subjective Symptoms.
(*a*) Pain.
(*b*) Photophobia.
(*c*) Increased lacrymation.
(*d*) Diminished vision.

The pain in iritis is usually very severe and persistent and can be quieted only by opiates. It is liable to be worse at night than during the day.

Photophobia and increased lacrymation are the natural results of the irritable condition of the diseased eye. Diminution of vision is caused by the presence of exudate.

B. Objective Symptoms.

(*a*) Exudation; hypopyon; hyphema.
(*b*) Discoloration of iris.
(*c*) Contraction of pupil.
(*d*) Ciliary injection.
(*e*) Steamy cornea.
(*f*) Unaltered or diminished tension.

*Exudation* takes place within the tissue of the iris, in the anterior chamber, and in the posterior chamber. Exudation within the iris itself causes the membrane to swell and to appear thicker than normal. Exudation in the anterior chamber causes the aqueous to become turbid. This condition is best recognized by the ophthalmoscope. The exudate may organize to form hypopyon. In case of rupture of the vessels of the iris, the blood settles at the bottom of the anterior chamber. The presence of blood in the anterior chamber is called *hyphema*. Exudation in the posterior chamber is recognizable only by its results. The exudate forms adhesions between the iris and the anterior capsule of the lens. These adhesions are called *posterior synechiæ*. If they are broken by the action of atropin, small brown spots of pigment are left on the anterior capsule of the lens and are proof of a former iritis.

*Discoloration of the Iris* is recognized by comparison of the diseased iris with that of the other eye if it is healthy. A blue or gray iris becomes greenish in hue. This change is due to congestion of the iris, and perhaps also in part to

the steamy condition of the cornea which usually accompanies iritis.

*Contraction of the Pupil* is the result of spasm of the sphincter pupillæ induced by pressure of the exudate within the iris.

*Ciliary Injection*, forming a pericorneal zone of redness, is always marked in iritis.

*Cloudiness of the Cornea* is due to the deposit of exudate upon the posterior surface of the cornea, or to actual infiltration in one or more of the posterior corneal layers.

The *tension* of the eye is usually normal in iritis. If affected at all, it is reduced.

*Course* and *Prognosis*.—Iritis may be either acute or chronic. Acute iritis presents more aggravated symptoms than the chronic form and runs a shorter course. Nevertheless, even most favorable cases of iritis do not entirely recover in shorter time than three months. Relapses are likely to occur, especially in the rheumatic type.

Syphilitic iritis yields more quickly to treatment than do other forms.

*Treatment* must be both constitutional and local. The causal disease should be combated by medication and by attention to hygiene. Rest is imperative. At the beginning of the attack, it is well to give enough calomel to produce mild purgation. Diaphoresis is to be recommended in plethoric cases.

Locally, pain is relieved by hot-water compresses applied at intervals during three or four minutes, several times a day. In severe cases leeching is of great service. Atropin should be instilled. The inflamed iris does not respond quickly, perhaps not at all, to the influence of the drug, but its use must be continued. Cocain often aids in dilating the pupil at the beginning of the attack, but after

dilatation has been accomplished the use of cocain should be discontinued. The eye should be shielded by dark glasses; it is best to avoid a bandage.

*Sequelæ.*—

1. In case the exudate organizes to form a membrane, *occlusion* of the pupil results. Occlusion of the pupil seriously diminishes vision but does not menace the future of the eye.

2. When a complete annular synechia forms between the iris and lens, communication between the anterior and posterior chambers is abolished and the condition is called *seclusion* (shutting off) of the pupil. Seclusion of the pupil affects the tension by interference with the normal flow of fluid within the eye, and in time causes blindness.

3. Exudation into the vitreous becomes organized and is recognized by means of the ophthalmoscope as vitreous opacities.

**Congenital Malformations of the Iris.**

*Coloboma* causes an alteration in the shape of the pupil similar to that caused by the operation of iridectomy, in which a portion of the iris is excised; but there are distinguishing marks between the congenital and the artificial coloboma. The former is always directed downwards, is lined at its edge by fibers of the sphincter pupillæ, and is usually observed in connection with coloboma of the ciliary body and choroid. The latter is usually directed upwards, has no muscle-fibers at its edge, and is not complicated by coloboma elsewhere in the eye. Congenital coloboma gives the pupil a shape like that of a pear; while artificial coloboma, owing to the sharp edges at its pupillary border, is compared in shape to a key-hole.

*Persistent pupillary membrane* is a retention of remnants of the embryological membrane which *in utero* closes the

pupil. It may be mistaken for posterior synechiæ, but its attachments can be seen to arise not from the pupillary margin of the iris but from its anterior surface. It is sometimes observed in the new-born, but soon disappears. Remnants may, however, persist throughout life.

*Aniridia* signifies absence of the iris. This defect is rare.

*Corectopia* signifies eccentric position of the pupillary opening of the iris. Normally, the pupil is a little to the nasal side, and a little below the center of the iris.

*Heterochromia* means differences in color in one iris, or difference in the color of one iris from that of the other.

**Injuries of the Iris.**

*Irido-dialysis* means separation of a part or the whole of the iris from the ciliary body. In incomplete separation a second opening in the iris is produced. Through this the red fundus-reflex can be seen, and often the edge of the lens and the ciliary processes are also visible. Such an injury as this alters the shape of the pupil, and because of the two openings may give rise to monocular diplopia. In complete separation aniridia is produced; the iris may be extruded through a wound of the cornea or sclera complicating the injury to the iris, or it may remain in the eye as a foreign body, in which latter case it shrinks into a very small mass.

*Punctured or penetrating wounds* of the iris demand the removal of any foreign body which may have lodged in the membrane, and care should be taken to prevent, if possible, infection of the eye-ball.

**Tumors of the Iris** are not infrequent. Gummata occur, also sarcomata, tubercles, and cysts.

## II. THE CILIARY BODY.

### Cyclitis.

*Etiology.*—The causes are the same as those of iritis.

*Symptoms.*—

A. Subjective.

Diminution of vision, due to exudation into the anterior chamber and into the vitreous, is especially marked in cyclitis. The eye is sensitive to pressure in the ciliary region.

B. Objective.

(*a*) *Exudation*, especially characteristic of cyclitis, is deposited upon the posterior surface of the cornea in the form of small particles arranged in the shape of a triangle whose base is downwards. The condition is often called "keratitis punctata," but the name is not a good one, for in many cases the cornea does not take part in the inflammation. This deposit of exudate may be found when no symptoms of iritis are present, which is a proof that cyclitis may occur independent of iritis.

(*b*) *Edema of the upper lid,* a symptom not present in iritis, is observed in cyclitis.

(*c*) *Tension* is at first increased in cyclitis owing to the presence of exudate in the eye; later, the tension is diminished as a result of shrinking of the exudate.

*Course* and *Prognosis.*—Simple cyclitis occurs rarely, and only in a chronic form. It is frequently protracted over some years. Inflammation of the ciliary body is always serious, and may lead to destruction of the eye.

*Treatment* should be directed to the cause. Local measures are similar to those used in iritis. Cases of cyclitis sometimes do not bear atropin well, owing to over-distention of the vessels of the ciliary body. If pain follows the in-

stillations, they should be discontinued. If the cyclitis is accompanied by decided rise of tension, a myotic should be used.

**Irido-cyclitis.**

This disease combines the symptoms of iritis and cyclitis, and occurs far more frequently than either disease alone. It shows a tendency to recur.

**Sympathetic Irido-cyclitis.**

This is an inflammation of the eye secondary to inflammation of its fellow. It is especially likely to follow inflammation due to traumatism. Actual inflammation is preceded by a prodromal stage, which may last days or weeks. During this period the patient notices increasing dimness of vision, sensitiveness to light, and pain in the eye. Later, the characteristic symptoms of irido-cyclitis develop, and the inflammation becomes violent. Sympathetic inflammation is most likely to occur at that time when the initial inflammation is at its height, *i. e.*, in cases of traumatism, from four to eight weeks after the injury. Recurrence of sympathetic inflammation is the rule, and the eye is ultimately destroyed. It is impossible to say at what time sympathetic inflammation may develop after injury or destruction of one eye. An injured eye, even if not blind, is always a menace to its fellow, and enucleation should in most cases be advised. After sympathetic inflammation has developed, enucleation of the injured eye has little or no effect upon the secondary inflammation.

# CHAPTER IX.

## DISEASES OF THE CHOROID, SCLERA, AND VITREOUS.

### I. THE CHOROID.

The choroid is essentially a vascular structure. It is usually described as consisting of five layers, three of which are composed of vessels. The innermost and the outermost layers are non-vascular and connective in type.

The vascular layers are distinguished from one another by the size of the vessels. The capillary layer is the inner one (*i. e.*, nearest the retina), the largest vessels are the outer ones, while the vessels medium in size form the middle layer. All the layers, except the inner connective and the capillary, contain pigment. The office of the choroid is that of supplying nourishment to the retina and vitreous. The nutrient blood-plasma exudes from the capillaries of the choroid and is appropriated by the tissues in proximity.

The vessels of the choroid show numerous anastomoses. They unite with vessels of the optic nerve, forming a circle about the disk; anteriorly, they unite with branches from the anterior ciliary arteries. In the normal fundus (with the exception of some eyes containing little pigment) the choroidal vessels can not be seen, but in case of disease or of congenital defect which destroys the choroidal pigment they appear as a network. This arrangement of the choroidal vessels distinguishes them from the retinal vessels, which do not form anastomoses. The capillaries of the choroid end at the anterior limit of the retina, the

jagged margin of which is called the *ora serrata*. The other layers of the choroid are continuous with the ciliary body.

**Choroiditis.**

In the choroid, as in structures in general, exudate is the evidence of inflammation. This exudate may resorb, or it may go on to suppuration. Hence two distinct varieties of choroiditis are described, the non-suppurative and the suppurative.

**Non-suppurative Choroiditis.**

*Etiology.*—The affection is often congenital. Syphilis, either inherited or acquired, is a prominent cause. The disease is sometimes dependent upon anemia, scrofula, and other constitutional disorders. Choroiditis is an almost constant accompaniment of advanced myopia, and in such cases is probably due to disturbance of the choroid caused by the continuous tension exerted upon that tissue.

*Course* and *Prognosis.*—The course is always chronic. The disease runs for many months, and its effects are permanent. It shows a tendency to recurrence. Syphilitic cases are the most promising, for they respond to energetic treatment.

*Symptoms.*—

A. Subjective.

*Disturbance of vision* comprehends the subjective symptoms of uncomplicated choroiditis. Since the retina lies close to the choroid, inflammation of the one can hardly exist without to some degree implicating the other. The exudate formed in choroiditis pushes forwards the retina lying over it, and images formed upon this part of the retina are consequently distorted. This perception of broken images is called *metamorphopsia*. Another annoying symptom is the perception of flashes of light. This is called *photopsia*.

Scotomata are due to atrophy of the retina at the foci of the choroidal inflammation. Frequently floating opacities exist as a result of the presence of organized exudate which has made its way into the vitreous. These may in time be wholly resorbed, especially if small, but generally they remain permanent as one of the evidences of previous choroiditis.

There is no pain connected with non-suppurative choroiditis, unless adjacent structures which possess sensory nerves become implicated. In case the inflammation spreads to the uvea, the usual symptoms of irido-cyclitis appear.

B. Objective.

The changes produced by simple choroiditis must be studied with the ophthalmoscope. Usually numerous foci of inflammation exist, with exudates which lie beneath the retinal vessels. These exudates, if recent, are yellow in color, and are easily outlined by comparison with the surrounding healthy red choroid. Upon the resorption of the exudate, the choroid is observed to be altered in proportion to the severity of the inflammatory process. More or less atrophy of the choroid has taken place. If this is but partial, remnants of vessels and pigment are found within the affected areas; but if the atrophy is complete, the choroidal vessels are absent and patches of white sclera are seen. Upon these patches pigment accumulates, owing to the tendency of pigment-epithelium to proliferate, and the edges of the white areas are bounded by pigment. In case the pigment-epithelium alone atrophies, leaving the vessels quite normal, the affected area has a reticulate appearance, owing to the anastomoses of the vessels. This appearance is sometimes physiological, as in the albino. It often accompanies myopia.

By *central choroiditis* is meant inflammation of the choroid at the macula. *Disseminated choroiditis* signifies inflammation of a scattered, irregular character. *Anterior choroiditis* exists at the anterior portion of the choroid, and because of its situation may easily escape notice.

Atrophy of the choroid at the margin of the disk manifests itself at first by the appearance of a narrow, yellowish crescent usually at the temporal side. As this increases in size it assumes a triangular shape, shows signs of advancing atrophic changes, and is then called a conus. Finally, when complete atrophy of the choroid is shown by the appearance of the white sclera, and the sclera itself yields to intraocular pressure and bulges backwards, the condition is known as *posterior staphyloma*. This is a frequent accompaniment of high myopia and is due to primary atrophy of the choroid caused by stretching of the tunics of the eye. The staphyloma may completely encircle the disk, when it is called "annular staphyloma," but, as a rule, it is limited to the outer side of the nerve-head.

*Treatment* must be directed to the cause, if this is discoverable. Syphilitic cases should receive vigorous antisyphilitic medication. Anemic cases should be given tonics and advised as to the importance of good food, fresh air, and attention to all details of hygiene. To hasten the absorption of the exudate, iodid of potassium is serviceable. Diaphoresis may be employed with good result. The eyes themselves should be relieved of all strain. It is good practice to instill atropin and to oblige the patient to wear dark glasses. Any error of refraction should be corrected. Complications should be treated in accordance with their nature.

**Suppurative Choroiditis.**

*Etiology.*—Infection is always the exciting cause and

may occur from without or from within. Penetrating wounds are the most usual media of infection. Infection from without may also occur as a result of suppurating ulcers of the cornea. Pyogenic germs may gain access to the interior of the eye through thin cicatrices which may be present in the anterior part of the eye as the result either of accidental wounds or of operations.

Infection from within may arise from pyemia or from meningitis.

*Course* and *Prognosis.*—The disease lasts as a rule from six to eight weeks, and in severe cases is followed by shrinking of the ball (phthisis bulbi) and total destruction of sight. The prognosis is bad, inasmuch as general inflammation of the structures of the eye (panophthalmitis) is almost inevitable. The pus may find exit by spontaneous perforation through the anterior portion of the sclera.

*Symptoms.*—

A. Subjective.
   (*a*) Violent pain.
   (*b*) Fever and vomiting.
   (*c*) Loss of sight.

B. Objective.
   (*a*) Edema of lids.
   (*b*) Intense injection of conjunctiva.
   (*c*) Chemosis.
   (*d*) Cloudiness of cornea.
   (*e*) Cloudiness of aqueous, with hypopyon.
   (*f*) All the signs of irido-cyclitis.
   (*g*) Elevation and subsequent diminution of tension.

If the media permit, the yellow exudate from the choroid may be seen with the ophthalmoscope. Extension of the suppuration affects one structure after another, until no part

of the eye has escaped involvement. The presence of exudate in the eye causes elevation of tension. As the inflammation subsides the eye becomes soft, shrinks, and loses its normal shape.

*Treatment.*—As nothing can be done to arrest the suppurative process, treatment must be directed towards relief of symptoms. The application of hot-water compresses is advised, and leeching may lessen pain; but recourse to narcotics is usually necessary. In case of undoubted panophthalmitis, incision of the sclera gives immediate relief. Enucleation of the eye while inflammation is present is not good practice, for the operation favors the extension of suppuration to the orbit and to the brain. The atrophied ball left after panophthalmitis is usually small enough to enable the patient to wear over it an artificial eye.

**Sarcoma of the Choroid.**—This disease is confined exclusively to adults, and occurs most frequently between the ages of forty and sixty. The clinical symptoms are not separable from those of glioma, but the latter disease is one of childhood. Enucleation should be performed.

**Tuberculosis of the Choroid** occurs usually in the miliary form. Small reddish spots appear in the fundus and rapidly increase in size and in number. Their existence in the eye may serve as a means of diagnosis in cases of suspected general miliary tuberculosis. A single tuberculous nodule may form in the choroid, and may so far increase in size as to ultimately rupture the sclera.

**Coloboma of the Choroid.**—By this is meant the absence of choroidal tissue at the lower part of the fundus. It is a congenital defect and is due to imperfect closure of the fetal ocular fissure. It appears as a brilliant white area somewhat triangular in shape, with base downwards. It often co-exists with coloboma of the iris. Colobomata vary in

size ; sometimes they are only as large as the disk, in other cases they are so large as to include the disk.

### II. THE SCLERA.

The sclera is one millimeter thick at its posterior portion. It becomes thinner as it approaches the anterior part of the eye. Loose connective tissue lies between the sclera and conjunctiva.

**Episcleritis.**

This is a localized inflammation affecting the superficial layers of the anterior part of the sclera.

*Etiology*.—A predisposing cause is adult or advanced age. The disease is often dependent upon the rheumatic diathesis.

*Course* and *Prognosis*.—Nodular foci of inflammation appear, each nodule having a period of development and resorption which lasts about two months. Successive nodules form in other parts of the sclera, and the disease runs an exceedingly chronic course. The nodules never break down to form ulcers, but disappear by resorption. They may leave no trace, but ordinarily a depressed, gray, cicatricial spot remains at the site of the nodule, and to this cicatrix the conjunctiva has become adherent. The disease usually attacks both eyes.

The prognosis as to the chronic course of the disease is unfavorable, but the disease does not seriously injure the eye.

*Symptoms*.—

A. Subjective.

The subjective symptoms are not characteristic. Pain may be slight or may be severe. The nodules are sensitive when touched.

B. Objective.

The appearance of a hard nodule, at the site of which is

moderate conjunctival injection, is the first sign of episcleritis. The nodule is adherent to the sclera, and previous to the stage of cicatrization the conjunctiva over it is movable.

*Treatment.*—If the cause can be found, it should be met by appropriate remedies. But treatment, as a rule, does not check the disease. Efforts should be made to relieve symptoms. Atropin is instilled, so that the eye may be set at rest. Hot-water applications relieve pain. In severe cases, leeching may be of benefit. Soothing collyria should be used for the sake of controlling the conjunctival irritation. Massage of the nodules is recommended as an aid to their resorption. A few drops of oil should be instilled into the conjunctival sac, then the lids should be closed while the affected part of the eye-ball is gently manipulated.

**Scleritis.**

This form of inflammation affects the deep layers of the sclera and is more diffuse than episcleritis.

*Etiology.*—As a rule, scleritis affects young adults. It occurs in patients suffering from syphilis, tuberculosis, and other debilitating diseases.

*Course* and *Prognosis.*—The disease does not, as a rule, remain limited to the sclera, but involves also the tissues of the uveal tract. Its course is chronic, and its results are very harmful to vision. Both eyes are usually affected. The prognosis is unfavorable, both as regards the course of the disease and its sequelæ.

*Symptoms.*—

A. Subjective.

Pain is present in proportion to the extent of the inflammation and the involvement of the other structures of the eye. Diminution of vision is noticed as soon as the cornea or the uvea becomes affected.

B. Objective.

The conjunctival injection is more general than in episcleritis, and combined with this is a peculiar bluish injection due to the congestion of the deeply-situated arteries. Nodules occur as in episcleritis, but they are not so circumscribed as those of the latter disease. The swelling is diffuse in character. The eye is sensitive to touch, especially after involvement of the uveal tract. The cicatrices which are formed by scleritis are dark-colored, and at their site the sclera is so much thinned that protrusions (ectasiæ) occur. In cases of extensive scleritis the whole eye-ball ultimately enlarges, and vision is entirely destroyed.

*Treatment* can not arrest the disease, although discovery and treatment of the cause may modify the attack. Pain and congestion are relieved by narcotics, hot-water compresses, and leeching. Atropin should be instilled. After all evidences of inflammation have disappeared, iridectomy may afford some vision, or may serve to prevent the occurrence of secondary glaucoma.

**Wounds and Neoplasms of the Sclera.**

Penetrating wounds of the sclera are particularly serious, because they open an avenue for infection, and the interior of the eye has been found to be a good culture-medium for germs. The introduction into the eye of a foreign body is to be regarded as even more serious than the occurrence of the wound alone. In a minority of cases the foreign body can be removed either with forceps or, if it is a fragment of iron, by the electro-magnet. Occasionally an eye will tolerate the presence within it of a foreign body, but as a rule it is best to perform enucleation in such cases, for sympathetic inflammation of the other eye may develop at any time. It is sometimes impossible to demonstrate the existence of a foreign body within the eye, for it may not be discoverable

by any method of examination. In such cases the physician must depend upon the history of the injury, and must watch the eye carefully to detect signs of serious inflammation.

The prognosis in wounds of the sclera must be guarded. The injured eye should be put absolutely at rest, thoroughly cleansed, and subjected to all ordinary surgical means for speeding healing.

**Tumors of the Sclera** rarely occur. Sarcomata and fibromata have been observed as primary neoplasms, and the sclera may be invaded by tumors originating in other parts of the eye or in the orbit.

### III. THE VITREOUS.

The vitreous is a gelatinous substance enclosed in a very thin membrane and supported by a reticulate framework. Anteriorly there is a depression (the fossa patellaris) in which rests the lens. In fetal life the hyaloid artery traverses the vitreous antero-posteriorly and carries nourishment to the lens. Persistence of this artery is sometimes seen in adult life, but as a rule the vessel disappears and only the lymph channel in which it originally ran remains. The vitreous contains no vessels and is nourished chiefly by the vessels of the uvea.

Effects of inflammation of the adjacent tissues appear in the vitreous as opacities of various size, shape, and consistence. Small floating particles (muscæ volitantes) are perceived by the patient and cause him much annoyance. Large opacities may affect vision. Opacities in the vitreous may resorb, but as a rule they persist throughout life. They are discovered by means of the ophthalmoscope, and the rapidity with which they move enables one to judge as to the condition of the medium in which they float.

**Synchisis** of the vitreous means a fluid condition of the humor. It is the result of destruction of the frame-work of the vitreous, and this in turn is dependent upon interference with the nutrition supplied by the adjacent tissues. The condition is a result of retinitis or of chronic diseases affecting the uvea. The failure of the vitreous to give its normal support to the retina and lens may occasion detachment of the retina and luxation of the lens. The presence of small opacities composed of cholesterin causes the ophthalmoscopic appearance of fine gold dust floating in the vitreous. This condition is called *synchisis scintillans.*

*Treatment* is directed towards the disease which causes disturbance of the vitreous. Iodid of potassium is an aid to absorption. Medication, however, is of service only in recent cases. Old opacities do not yield to any form of treatment. Their presence does not in any way menace the safety of the eye.

# CHAPTER X.

## DISEASES OF THE OPTIC NERVE AND RETINA. GLAUCOMA.

### I. THE OPTIC NERVE.

The entrance of the optic nerve is a little to the nasal side of the center of the eye. At this point the inner layers of the sclera, together with some lamellæ of the choroid, form a network called the *lamina cribrosa*, through whose interstices pass bundles of nerve-fibers.

After passage through the lamina cribrosa, the fibers are found to have lost their myelin, and to have become, therefore, transparent and reduced in size. Occasionally, some or all of the fibers may retain their medullated structure after passage through the lamina cribrosa. The retained sheaths show as opaque areas of various sizes and with feathery edges. The retinal vessels are frequently obscured during a part of their course by these retained nerve sheaths. Vision is not affected by their presence, but the perimeter shows an increase in the size of the blind spot. At the lamina cribrosa the envelopes of the eye are least able to resist increased intraocular pressure. At this point, also, the nerve is so tightly enclosed by the firm scleral tissue that edema within or about the sheaths of the nerves causes strangulation of its vessels (choked disk). In spreading out into the retina, all the nerve-fibers do not separate from one another upon the same plane. The central fibers usually separate at a lower level, and thus a physiological excavation, or "cup," is

formed. Moreover, a greater number of fibers pass to the nasal side of the disk than to the temporal, thus making the nasal portion of the disk slightly redder in color, and that side of the cup steeper. From the temporal side of the nerve run special fibers to the macular region. They are known as the "papillo-macular bundle," and are disposed in the form of a triangle the apex of which is at the disk. The sheaths of the optic nerve are continuous respectively with the pia mater, arachnoid, and dura mater of the brain, and within the eye they are continuous with the sclera. Anatomically the substance of the optic nerve resembles the white matter of the brain. The central retinal artery is a branch of the ophthalmic artery. The central retinal vein empties either into the superior ophthalmic vein or directly into the cavernous sinus. The optic nerve is penetrated by the retinal vessels at a point from ten to twenty millimeters behind the eye. The greater number of fibers of each optic tract arise in the cerebral cortex, pass through the internal capsule and optic thalamus, and join the fibers of the opposite optic tract to form the chiasm. Fibers from several sources enter the optic tract, one of the most important sets being that from the nucleus of the third nerve. At the chiasm, which lies about one centimeter behind the eye, a semi-decussation takes place (see Fig. 16). The fibers at the outer side of each tract do not decussate; they simply make an angular bend and pass on to the eye on the corresponding side of the body. The inner fibers of each tract cross one another and blend with those of the nerve of the opposite side.

The right optic tract receives stimuli from the temporal side of the right eye and from the nasal side of the left eye; the left tract receives stimuli from the temporal side of the left eye and from the nasal side of the right eye. All ob-

jects, therefore, situated on the right send stimuli to the left optic tract and thence to the left hemisphere of the brain; similarly, objects on the left are perceived by the right hemisphere. A lesion produces ocular effects in accordance with the situation of the injury. Monolateral defects must be produced by injuries in front of the chiasm, while bilateral defects depend upon lesions of the tracts. For example, if a lesion affect the right optic nerve (*i. e.*,

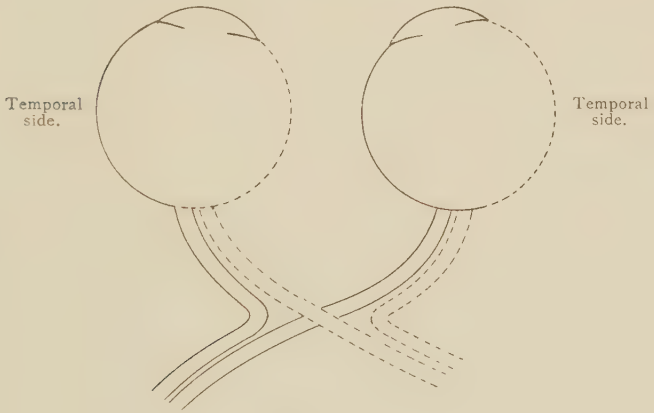



Fig. 16.

in front of the chiasm) total blindness of the right eye will result; whereas, if a lesion occur behind the chiasm and affect the right tract, blindness of the temporal side of the right eye, together with blindness of the nasal side of the left eye, will follow. The latter affection is known as *hemiopia*.

**Optic Neuritis.** Inflammation of the nerve may or may not involve the visible part, hence two varieties are described, the *intraocular* and the *retro-bulbar*.

**Intraocular Neuritis.**

Gowers* distinguishes three stages of this variety: (*a*) *Simple congestion*, in which increased redness of the disk is observed but no swelling nor obscuration of its edge. (*b*) *Congestion with edema*, in which there is increased redness, and sufficient swelling to obscure the edge of the disk to direct examination but not enough to blur it to the indirect method. (*c*) *Neuritis proper*, in which there is decided swelling and redness of the disk, with total obscuration of the edge (localized or general) both to direct and indirect examination.

Both the direct and the indirect method should be employed in the examination of a case of suspected optic neuritis, for the edge which seems blurred to the direct method may be perfectly clear to the indirect. This apparent obscuration depends upon the fact that the direct method affords opportunity for sharper focusing, and thus brings into view the opaque fibers which curve over the edge of the nerve to pass into the retina; while the indirect method seems to bring the nerve fibers and the choroid to the same level and, therefore, to more sharply define the one from the other.

*Etiology.*—(*a*) Neoplasms either in the nerve itself or in its vicinity.

(*b*) Neoplasms and diseases of the brain.

(*c*) Constitutional diseases, as syphilis (either by direct infection or by pressure of neoplasms due to syphilis), diabetes, nephritis, tuberculosis.

(*d*) Acute infectious diseases, as scarlet fever, diphtheria, small-pox, pneumonia.

(*e*) Acute anemia.

* "Medical Ophthalmoscopy," page 43.

(*f*) Lead poisoning.

*Course* and *Prognosis.*—The disease is always chronic, lasting many months. In some cases the neuritis does not reach its climax within a year. Atrophy follows, and this is proportionate to the degree of the neuritis. The prognosis is grave. Syphilitic cases (especially those of the less severe type) may entirely recover under prompt and vigorous treatment. Some impairment of vision, however, is almost inevitable.

*Symptoms.*—

A. Subjective.

Disturbance of vision, including contraction of field, is the most prominent symptom, but this is sometimes absent even in severe cases. Sensitiveness to light and pain in the head may be present.

B. Objective.

There are no external signs, except, perhaps, dilatation of the pupil due to diminution of vision. The ophthalmoscope shows the disk to be very red. Hemorrhages may occur upon its surface. Owing to compression of the nerve by swelling, the arteries appear small and the veins large and tortuous. The inflammation may be confined to the disk or may involve the retina also, in which latter case the condition is called *neuro-retinitis.* In any case of severe neuritis the nutrition of the retina is more or less affected, and a result of this is shown, on subsidence of the inflammation, by the appearance of white spots in the retina. These resemble those seen in albuminuric retinitis.

*Treatment* must be directed to the cause. In cases of obscure or doubtful origin, iodid of potassium may be relied upon as a good remedy to promote absorption of exudate.

Diaphoresis and abstraction of blood by leeching should

be practiced in severe cases. The urine should be subjected to careful and repeated examinations.

**Retro-bulbar Neuritis.**

In this affection of the optic nerve there are often no signs within the eye until those of atrophy appear. The disease may be either acute or chronic. In the acute form the causes are (*a*) exposure to cold, (*b*) acute infectious diseases, (*c*) poisoning from such drugs as lead, chloral, and alcohol. The chronic form develops as a result of habitual abuse of tobacco or of alcohol.

The prognosis is more favorable than in cases of intra-ocular neuritis, for under prompt and appropriate treatment patients often recover full vision in the course of a few months. In acute attacks vision fails suddenly and there is usually violent headache. No external symptoms of eye trouble are seen, except dilatation of the pupil due to loss of sight. In cases caused by poisoning from tobacco the loss of vision is gradual and is called "tobacco amblyopia." Both eyes are usually attacked at the same time and to about the same extent. Examination of the field of such a patient usually reveals a central scotoma. At first this is for color only, but later it tends to become complete.

*Nyctalopia* (day-blindness) is an evidence of central scotoma. The patient complains of not being able to see as well during the day as at night. This is due to the fact that under reduced illumination the pupil tends to dilate, and the unaffected peripheral portion of the retina receives impressions.

Abstinence from the habit which causes the neuritis constitutes the most important detail of the treatment. Iodid of potassium and strychnia are standard drugs in this affection. The eyes should be protected from irritation and from over-use.

**Atrophy of the Optic Nerve.**

This affection may be *primary* (non-inflammatory) or *secondary* (following inflammatory processes).

*Primary Atrophy.*

*Etiology.*—(*a*) Diseases of the brain and of the spinal column are the chief causes, locomotor ataxia and disseminated sclerosis being the most prominent. The Argyll-Robertson pupil (*i. e.*, the pupil which responds to convergence but not to light) and the absence of patellar reflex are usually discovered in connection with optic atrophy due to locomotor ataxia. (*b*) Pressure upon the nerve by tumors or by exudates may cause atrophy. (*c*) Injuries of the skull or of the nerve itself are not infrequent causes.

(*d*) Simple atrophy is seen most frequently in patients of middle age.

*Course* and *Prognosis.*—The course is chronic, and treatment seems powerless to arrest the progress of the atrophic changes.

*Symptoms.*—

A. Subjective.

Loss of sight and contraction of field become gradually more and more marked, until total blindness ensues. Inability to recognize colors is an early symptom.

B. Objective.

The nerve-head gradually acquires an abnormal pallor and becomes at last perfectly white or bluish-white in color. The retinal vessels do not markedly change in appearance, for in simple atrophy they are not pressed upon by exudate. The lamina cribrosa is plainly seen.

*Treatment* is of little use; nevertheless, the cause of the disease should be discovered and combated if possible. Strychnia is given in large doses.

*Secondary Atrophy.*—The causes are those of neuritis

in general. The atrophy left as a result of neuritis is usually not of the progressive type. Whatever vision remains after the neuritis has subsided is likely to suffer no farther impairment. The ophthalmoscope reveals certain signs by which primary and secondary atrophy can be distinguished. In secondary atrophy the veins are enlarged and tortuous, the disk gray in color and crossed by strands of connective tissue formed from exudate. In a late stage the disk becomes white, shrunken, and irregular in outline; the vessels are greatly reduced in size. In this form of atrophy the lamina cribrosa is hidden from view. (Compare objective symptoms of primary atrophy.)

*Treatment* must be directed to the cause. Iodid of potassium and strychnia serve well as tonics. Antiphlogistic remedies should be used in some cases.

### II. THE RETINA.

The only two places at which the retina is attached to other tissues of the eye are its anterior border (the ora serrata) and the optic nerve. The retina rests upon the choroid and is held in position by the vitreous. The fibers of the optic nerve form the fiber-layer of the retina and by connection through the intermediate layers end in the rods and cones. At the fovea the retina is thinnest; here cones are present but no rods, and each cone receives a separate nerve-fiber. Rods begin to occur at the border of the macula and become more and more numerous toward the periphery of the retina. The external (posterior) layer of the retina is composed of pigment-epithelium which separates the layer of rods and cones from the choroid.

The retinal vessels lie in the more anterior layers of the retina. The posterior layers, therefore, are dependent upon the choroid for nourishment. The vessels of the retina

form no anastomoses (except very minute ones with the ciliary vessels), and for this reason collateral circulation can not be established.

**Retinitis.**

*Etiology.*—Retinitis is most often produced by constitutional diseases, the most prominent being nephritis, diabetes, leukemia, and syphilis. Rarely cases occur due to local causes, such as exposure of the retina to brilliant light or prolonged strain of the eyes.

*Course* and *Prognosis* depend upon the cause and upon the severity of the attack. As a rule, patients recover very slowly, and the disease drags on through many months. Hemorrhages into the retina may be absorbed and leave no trace, but usually they are replaced by opaque areas which may or may not become pigmented. Permanent impairment of vision is a usual result of neuritis, and is proportionate to the severity and extent of the inflammation. Opacities frequently occur in the vitreous as a sequel of the disease. Retinitis is likely to recur and to lead to atrophy with pigmentation of the retina. The prognosis, therefore, is always grave.

*Symptoms.*—Retinitis is accompanied by disturbances and diminution of vision, headache, and sensitiveness of the eye to light. Objectively, the fundus shows a diffuse cloudiness which is most pronounced in the region of the disk. The edges of the disk are blurred. The vessels are distended and tortuous. Hemorrhages often occur, and that type of retinitis in which hemorrhages constitute the predominant symptom is called "retinitis hemorrhagica."

The objective phenomena vary in accordance with the type of retinitis.

(*a*) Albuminuric Retinitis.

The ophthalmoscopic appearances are characteristic. In

a typical case, a stellate figure composed of small, brilliant, white spots is seen at the macula. Spots are usually discovered also in other parts of the fundus. Hemorrhages following the direction of the fibers, and hence flame-like in shape, are found in the region of the disk; they occur also in other parts of the retina.

(*b*) Diabetic Retinitis.

White spots are found in the retina, but they are not likely to be so circumscribed and brilliant as those of albuminuric retinitis, nor so regularly arranged about the macula. Hemorrhages of the retinal vessels often occur in this variety.

(*c*) Leukemic Retinitis.

This affection is characterized by a peculiar yellow tinge of the fundus, due to the altered state of the blood.

(*d*) Syphilitic Retinitis.

In this form diffuse opaque areas are seen. The retinal vessels are distended and tortuous, and the disk's edge is obscured. Dust-like opacities form in the vitreous. Syphilitic retinitis usually co-exists with syphilitic iritis.

*Treatment* must be both constitutional and local. Syphilitic cases respond to specific medication. General tonic treatment together with mild purgation should be employed. The eyes should be protected from light and their use should be prohibited. Examination of the urine in cases of albuminuric retinitis may or may not reveal the presence of albumin.

**Atrophy of the Retina.**

This is a sequel of retinitis, or it may be the result of some disturbance of the circulation, and, therefore, of the nutrition of the retina. The disk shows signs of secondary (retinitic) atrophy. The vessels become small and at last disappear.

A special variety of atrophic change in the retina is that known as *pigmentary degeneration* (retinitis pigmentosa). Small black spots appear first in the peripheral portion of the retina; these branch and join one another, and new spots form in more central parts of the fundus. They lie over the retinal vessels, and are in this way distinguished from the spots formed by disturbance of choroidal pigment. In the latter instance the retinal vessels pass over the areas of degeneration. Gradually the retina loses function, until after a lapse of years blindness results. The most prominent subjective symptom in the disease is night-blindness (hemeralopia). Patients see well during the day, but as night approaches their vision becomes impaired. This symptom becomes evident not only from the patient's statement, but also from examination of the field of vision, first under good illumination and then by dim light. The field will show marked limitation during the examination by dim light, and from this it may be inferred that the peripheral portions of the retina are not normally sensitive. This annoying symptom increases with the age of the patient. The disease attacks both eyes, and is most frequently observed in children and in males. The prognosis is bad, for blindness is sure to follow, even if slow in its approach. Treatment is of no avail.

**Detachment of the Retina.**

*Etiology.*—Since the retina retains its position by reason of the pressure of the vitreous (see page 132), any diminution in volume of this humor allows the retina to float forward. Diseases of the uvea may cause exudates in the vitreous, and subsequent shrinkage of these exudates not only affects the function of the vitreous as a support to the retina, but in some cases even causes the vitreous to exert traction upon the retina. On the other hand, tumors,

exudates, or hemorrhages lying behind the retina may overcome the normal pressure exerted by the vitreous and force the retina from its position. Traumatism is a frequent cause of detachment of the retina. The condition is likely to result from any injury, either accidental or operative, which is followed by loss of vitreous.

*Course* and *Prognosis.*—Detachment may occur either suddenly or gradually. The time required for recovery varies in accordance with the extent of the detachment and the cause. Recurrence is usual. A partial detachment tends to become total. The prognosis, therefore, is in general unfavorable, but it must be governed by the extent and situation of the detachment.

*Symptoms.*—

A. Subjective.

Disturbed vision, with limitation of field, is experienced. The patient complains of seeing a dark cloud over that part of the field which corresponds in location to the retinal detachment. If, for example, the detachment is in the lower part of the fundus (and this is the most usual situation), the patient sees only the lower part of objects. Headache is usually a symptom.

B. Objective.

Externally the eye looks normal, except for a deep anterior chamber due to the recession of the lens which accompanies loss or shrinkage of the vitreous. This disturbance of the vitreous also causes a diminution of tension. The detached retina is seen with the ophthalmoscope as a gray membrane projecting into the vitreous. With a plus lens the extent of this projection may be measured. Vessels can be traced from the disk to the limit of the detached retina, where they bend suddenly and reappear upon the surface of the detached portion. Fluid lying underneath

the retina causes "undulation" of the membrane on movement of the eye. The sub-retinal fluid tends to sink and so to detach the retina lower down in the fundus.

*Treatment.*—Rest should be insisted upon, and a pressure bandage should be applied over the affected eye. Diaphoresis and mild purgation should be employed, and iodid of potassium given as an absorbent. Puncture of the sclera at the situation of the detachment is often practiced. By this means the sub-retinal fluid is removed, but as it tends to re-accumulate, the results of operative procedure are not enduring. When detachment is due to a neoplasm, enucleation should be performed. A cysticercus may be extracted through an incision of the sclera.

**Glioma** of the retina is the only variety of tumor found in this tissue. It occurs usually in children under five years of age. A bright white or yellow reflex from the pupil is an early external sign. This is due to detachment and degeneration of the retina. As the tumor develops, the eye enlarges, and the tumor projects from the orbit, forming a large, ulcerating mass. The neighboring glands become affected, the brain is involved by extension of the process backwards along the optic nerve, and by metastasis the internal organs suffer. The disease runs its course through several years, and patients die either from exhaustion or from involvement of other organs. Glioma usually occurs in but one eye. With the increase of tension the patient has pain, which becomes more and more severe as the tumor enlarges.

*Treatment* consists in enucleation in all cases. Early enucleation promises possible cure; but even if recovery can not be expected, much suffering is spared by a removal of the tumor. The nerve should be divided as far back as possible.

**Disturbances of Vision without Perceptible Retinal Changes.**

*Uremic Amaurosis* is sudden loss of vision due to retention of urinary constituents. It is a transient affection. Other symptoms of uremia co-exist.

*Amblyopia ex anopsia* is loss of visual acuity through non-use of the eyes. It is due to a variety of causes, the most prominent of which are opacities in the media and strabismus. Normal vision cannot be restored by the use of glasses, although in children a developing amblyopia may be overcome to some extent either by tenotomy or by wearing glasses, or by a combination of the two methods of treatment. Amblyopia is usually a unilateral affection. In case it is bilateral, nystagmus (oscillation of the eyes) develops.

*Color Blindness.*—The inability to correctly perceive colors may be either partial or total. There are two principal theories to account for this condition.

I. *The Young-Helmholtz Theory.* — This assumes the presence in the retina of three separate kinds of fibers, each kind corresponding to a primary color. Every kind of light affects all these fibers at the same time but not to the same degree. A red ray stimulates most energetically the fibers corresponding to the color red, less so those corresponding to green, and least of all those corresponding to violet. Green affects especially the fibers belonging to that color, has less influence upon the red, and least influence upon the violet. Similarly, a violet ray affects especially the fibers corresponding to that color, and affects to a less degree the fibers belonging to red and to green. "Red-blindness" is caused by an absence of the fibers corresponding to the color red. A red ray falling upon such a retina stimulates the other fibers, but only with compara-

tively slight effect. The patient perceives the ray as green but not as a brilliant green. He learns to connect this perception of a modified green with the idea of red, and to think similarly in regard to other colors. He therefore becomes expert in perceiving shades of difference, and often gives to colors their correct names without having at any time actually perceived them. For this reason it is sometimes difficult to convince partially color-blind people that they do not possess normal perceptive power.

II. *Hering's Theory.*—This assumes the existence in the retina of a "visual substance," which, like tissue everywhere in the body, is subject to disintegration and regeneration. Besides a black-white element, two others are assumed to exist in the visual substance, namely, the red-green and the blue-yellow. The colors of each pair are complementary; disintegration of the one substance is accompanied by regeneration of the other. Each substance is affected only by that kind of ray which possesses a corresponding valence. A pure red ray, for instance, causes in the red-green element a disintegration of the red and a regeneration of the green. A mixed color, as violet (composed of blue, red, and white), acts both upon the red-green and the blue-yellow element. Every color contains in it a white valence which serves to give brilliancy to the color. Each pair of colors, then, has three valences, one belonging to each color and one white. Absence of one or both color elements of the visual substance explains color-blindness. Pure red and pure green rays exert only their white valence upon the visual substance of an eye that is red-green blind.

*The examination for color-blindness* is conducted by placing before the patient several skeins of worsted of colors which are easily confounded with one another. A certain color (as, for example, pure red) is selected and the patient

told to place with it all the skeins which resemble it. If red-blind, he will select not only the shades of red, but also the pale shades of other colors. Lack of perception for red is the most usual defect.

### III. GLAUCOMA.

This disease represents one per cent. of all affections of the eye. The symptoms observed in its course are due to increase of intraocular tension; but a completely satisfactory explanation of the reason for this increase has not yet been reached. The capacity of the tunics of the eye is assumed to be invariable, therefore increase in intraocular tension must be accounted for by change in the volume of contents. This, in turn, depends upon the relation between secretion and excretion. Several theories have been advanced, most of them founded upon the idea of increase of inflow, but the theory now generally accepted is based upon the idea of decrease of outflow. It originated with Knies and Weber and may be outlined thus: Venous stasis causes the ciliary processes to swell; they press against the iris, which in turn is pushed forward against the anterior limit of the sclera and the edge of the cornea. The normal exit for the fluid of the anterior chamber is thus closed. Moreover, the iris presses against the ligamentum pectinatum and closes the entrance of the most important means of escape of intraocular fluid, the canal of Schlemm. Cases of glaucoma have been observed, however, in which this canal is open, hence the theory can not be said to be applicable in all instances. Slight increase of tension is designated by +; a decided increase by + 1; very high tension by + 2; while the sign + 3 shows that the eye is as hard as stone. Diminution of tension is similarly expressed by use of the sign —.

Glaucoma is described under the divisions—

1. Primary. { Simple. / Inflammatory.
2. Secondary.

**I. Primary Glaucoma** is that variety whose origin is independent of other preëxisting disease of the eye.

(*a*) **Simple Glaucoma** develops insidiously and shows no external signs of inflammation.

*Etiology.*—The venous engorgement which predisposes to glaucoma is the result of disturbances of the circulation caused by lesions of the heart or of the vascular system.

*Course* and *Prognosis.*—The development of the disease is very gradual and occupies several years. Vision fails little by little, until complete blindness results. *Absolute glaucoma* is the name given to that stage of the disease in which there is total blindness. Abscess of the cornea or panophthalmitis may attack the eye, and atrophy of the globe follow. Both eyes are always affected, although usually not at the same time. If early iridectomy is done, an arrest of the disease in the affected eye can probably be obtained, but restoration of normal vision is impossible.

*Symptoms.*—

A. Subjective.

These are confined entirely to disturbances of vision, unless the glaucoma becomes inflammatory in type. Central vision is gradually lost, and at the same time the field becomes more and more contracted.

B. Objective.

Externally, signs of the disease are few and not marked. This is due to the fact that intraocular tension increases very gradually. The pupil is dilated and sluggish, the anterior chamber is shallow, and the anterior ciliary veins distended. The cornea is usually somewhat insensitive.

The ophthalmoscope shows a complete excavation of the nerve-head, the depth of the excavation depending upon the stage of the disease. The retinal vessels are distended and tortuous, and pulsation of the arteries is often observed.

*Treatment.*—Iridectomy should be advised in most cases. At least one-fifth of the iris should be removed. The details of the operation are given in Chapter xii. A repetition of the iridectomy is often necessary in this variety of glaucoma. If the eye is blind and painful, enucleation is indicated.

A solution of eserin (gr. $\frac{1}{4}$ to f℥j), one drop in the eye two or three times a day, reduces tension and may improve vision, if operation is refused or for some reason is contraindicated. The abnormality of the patient's circulatory system should be ascertained and treated.

(*b*) **Inflammatory Glaucoma.**

This variety is accompanied by external signs of inflammation. An especially violent and rapidly destructive form is called *glaucoma fulminans.*

*Etiology.*—Predisposing causes are inheritance, age (between fifty and seventy), and sex (women are more likely to be affected than men). The hypermetropic eye is said to be predisposed to the disease, while myopic eyes are very seldom attacked.

The venous engorgement which precedes an attack of inflammatory glaucoma may be due to emotional excitement, excessive physical exertion, or to other kindred causes. Artificial dilatation of the pupil is another cause. A drop of a mydriatic in an eye predisposed to glaucoma may precipitate an attack of the disease. In case this occurs, the effects should be immediately combated by the use of a myotic.

*Course* and *Prognosis.*—Each attack lasts a variable time,

some only a few days, others some weeks. Attacks occur at intervals varying widely in length of time but tending to follow one another more rapidly as the disease progresses. Several years are likely to pass before sight is lost. In *glaucoma fulminans*, however, blindness occurs in the course of a few hours.

If early iridectomy can be done, the prognosis is good. Not only are the inflammatory symptoms subdued, but the arrest of the disease is permanent.

*Symptoms.*—

A. Subjective.

The prodromal symptoms in the inflammatory type of glaucoma are significant. The patient notices that at times his vision is dimmed and that rings of color seem to surround every light he sees. His eye feels full, and he suffers from dull headache. Several hours pass and these symptoms disappear. Sleep will relieve them at once; this is supposed to be due to the extreme contraction of the pupil during sleep. These prodromal attacks become frequent and finally usher in true inflammatory glaucoma. The ocular pain now is violent, because of pressure of exudate upon the sensory nerves of the ciliary body and iris, and it radiates in the courses of the first and second branches of the trigeminus. Vision is much reduced; this is due to two conditions, namely, haziness of the cornea from exudate and anemia of the retina caused by compression of the retinal arteries. The cornea is insensitive to touch, for the ciliary nerves are paralyzed by pressure of exudate.

B. Objective.

In the prodromal stage the external symptoms are not conspicuous, but they are always present in greater or less degree. The cornea is cloudy, the anterior chamber shallow, the pupil dilated and sluggish. There is slight ciliary injection and increase in tension.

During an acute attack all these symptoms are intensified and are accompanied by other signs of inflammation. The conjunctiva now shows a marked, dark-red congestion due to venous engorgement. The cornea is opaque and dotted by minute collections of exudate. The sphincter pupillæ is paralyzed by pressure, and therefore the pupil is widely dilated and unresponsive. There is a greenish reflex from the pupil. This symptom gave the disease its name. (See Glossary of Derivations.) The iris is edematous and discolored. The anterior chamber is shallow because the lens is pushed forward by the increase of fluid within the eye. The tension is decidedly increased.

Ophthalmoscopically, nothing can be seen because of the steamy cornea. Excavation of the nerve is not observed until after the disease is well established. During intervals between the inflammatory attacks the lamina cribrosa is seen to have receded before increased intraocular tension, and the optic nerve-fibers have suffered from pressure. The whole surface of the disk is sunken. The blood-vessels make a sharp bend at the margin of the disk. There are three principal varieties of excavation of the optic nerve, and it is important to know the differences in their ophthalmoscopic appearances.

1. *The physiological* is partial, and the lamina cribrosa is unaffected.

2. *The atrophic* is entire (*i. e.*, it involves all the fibers of the nerve-head), shallow and white. The lamina cribrosa is intact.

3. *The glaucomatous* is entire, not white until late in the disease, and deep. The lamina cribrosa has receded.

Late in the disease a ring of atrophied choroid surrounds the disk. It is called the "glaucomatous halo."

*Treatment.*— Iridectomy, if performed early, promises

good and lasting results. Obstacles to successful operation are offered by the shallow anterior chamber, the inflamed, friable iris, the cloudy cornea, and the general condition of the patient. Iridectomy is better done in the prodromal stage, if possible. It is not known why iridectomy diminishes increased tension. It may be that free excision of the iris establishes a direct anastomosis between the arteries and veins at the ciliary border of the iris.

De Wecker thought that the decrease of intraocular tension which followed iridectomy was due really to the oozing of fluid through the scleral wound, and this idea gave rise to the operation of *sclerotomy*. (See Chapter xii.) The operation is not so sure in its results, however, as is iridectomy. Enucleation is done only when the eye is painful and sightless. Myotics serve to abort attacks in the prodromal stage, and in acute attacks they lessen pain. A myotic should always be instilled, whether iridectomy is to be performed or not; for in the one case the operation is more easily performed, and in the other the pain is lessened and perhaps the attack is aborted or shortened. Eserin or hydrochlorid of pilocarpin may be used, in one or two per cent. solutions.

**II. Secondary Glaucoma.**

This type of glaucoma occurs as the result of ocular disease or injury. The most important conditions and affections which become complicated by increase of intraocular tension are the following :—

1. Luxation or swelling of the lens. Either of these conditions may result from accident or from operation.

2. Intraocular tumors, as gliomata.

3. Hemorrhages into the retina (glaucoma hemorrhagicum).

4. Iridocyclitis, by increasing the amount of fluid in the eye through exudation.

5. Seclusion of the pupil, which favors the accumulation of fluid in the anterior chamber.

6. Staphylomata which include the iris.

*Treatment* should be directed to the cause. A luxated or swollen lens should be removed; enucleation of the eye should be performed in case of intraocular tumor; other conditions indicate paracentesis of the cornea or iridectomy.

# CHAPTER XI.

## DISEASES OF THE LENS. DISEASES OF THE ORBIT.

### I. THE LENS.

The lens (crystalline body) is a transparent, colorless structure, convex in shape. The lens of a grown person measures about five millimeters from the center of its anterior to that of its posterior surface, and about nine millimeters around its edge. The posterior surface is somewhat more curved than the anterior. The central anterior and posterior points of the lens are called the anterior and posterior *poles;* its margin is known as the *equator.* The central portion, which in the lens of an adult is always somewhat hardened, is called the *nucleus*, while the remaining peripheral portion is called the *cortex.* The lens is an epithelial structure, and is divided into "sectors" by fibers which are so disposed as to form a Y-shaped figure. This arrangement of fibers can be recognized, with the aid of oblique illumination, in the lens of an adult, especially in cases of progressive cataract. The lens is enclosed by a homogeneous membrane, called the capsule, which is somewhat thicker in its anterior than in its posterior portion. On the inner side of the anterior portion are epithelial cells, from which the fibers of the lens originate. The *suspensory ligament* (Zonula of Zinn) takes its origin from the ciliary body, and holds the lens in position between the vitreous and iris. The lens is a refracting medium, and the changes which occur in its curvature make accommodation possible. The process of gradual sclerosis of the nucleus begins in

childhood, but does not perceptibly affect the function of the lens until about the age of forty years, when accommodation begins to fail because of loss in elasticity of the lens. Sclerosis of the nucleus causes a grayish reflex from the pupil, which on superficial examination may be mistaken for cataract.

Disease of the lens is restricted to opacity of its structure. Opacities may occur in various shape, size, and density. All opacities are, however, grouped under the term—

**Cataract.**

"Glaucoma" was the early name given to opacity of the lens, because of the gray reflex from the pupil. It was believed to be due to the accumulation of fluid between the iris and lens, and because of the idea that the fluid was poured from above downwards the name "cataract" was afterwards substituted. It was not until 1705 that the true nature of cataract became known.

*Etiology.*—Opacity is probably due to interference in the nutrition of the lens, but the direct causes of this interference are not well known. (*a*) The disease is observed to occur in members of the same family, although the same type of cataract may not develop in every case. (*b*) The congenital variety usually affects both eyes. (*c*) Diabetes is often complicated by rapidly progressive cataract which is always bilateral. (*d*) Traumatism is a frequent cause of cataract. Any injury which opens the capsule causes the lens to imbibe fluid, swell, and become opaque. (*e*) Senile cataract is the most frequent type; it does not as a rule occur until after the age of fifty. (*f*) Certain diseases of the eye may give rise to opacity of the lens, as, for instance, iridocyclitis, choroiditis, retinitis, absolute glaucoma.

*Varieties of Cataract.*

*Lenticular* cataract signifies opacity of the lens itself, while

*capsular* cataract means opacity of the capsule. When opacity occurs in both the lens and the capsule, the combination forms a "capsulo-lenticular" cataract.

**I. Lenticular Cataract.**—Opacities are found in various parts of the lens substance; if situated in the periphery, a mydriatic is often necessary for their discovery. With the ophthalmoscope opacities show as dark spots or striæ. They are distinguished from vitreous opacities by the fact that they do not change their position on movement of the eye.

Opacity of the lens begins by a separation of its fibers and the accumulation of fluid between them. Later the fibers themselves degenerate and the lens shrinks away from its capsule. Resorption of fluid may occur, but the lens fibers are never regenerated. Cataract may be *partial* (involving only a part of the lens) or *total* (involving the entire lens).

*Central* cataract is confined to the center of the lens. *Fusiform* cataract extends from pole to pole and has a slight swelling at its center. *Punctate* cataract shows as small dots of opacity scattered throughout the lens or collected together in some one or more portions. *Zonular* (*lamellar*) cataract is the most frequent variety of lenticular cataract observed in children. It may be congenital or may develop during early years of life. The opacity occurs in the lamellæ which lie between the nuclear and cortical portions. It leaves a clear nuclear and a clear peripheral portion. Usually, the opacity is covered by the undilated pupil and vision is not at all impaired. In other instances, however, the opacity encroaches upon the pupillary area. The zone of opacity is darkest at its periphery, and at this edge occur small spicules of opacity projecting from the zone like the spokes of a ship's wheel. These in

reality are curved over the edge of the zone, fitting it, as it were, like saddles; they are therefore called "riders." Their presence shows that other lamellæ are becoming involved in the opacity. This form of cataract usually affects both eyes. It is found most often in children of rachitic tendency; it may be inherited. Usually it remains stationary, but it may develop and ultimately involve the entire lens.

*Cortical* cataract occurs at either the anterior or the posterior portion of the lens. It appears in the form of a stellate figure whose center is the pole, and whose rays extend towards the periphery. Posterior cortical cataract is the one more usually seen. It occurs as a result of other diseases of the eye, as choroiditis. Vision is usually much affected, both because of the opacity and the causal disease. The cataract may remain stationary or may become progressive.

*Progressive* cataract passes through a number of stages from partial to total opacity. The time consumed in this process varies from hours to years. Senile cataract is a type of this variety. In the incipient stage, spicules of opacity are found in certain portions of the lens, while other portions remain perfectly transparent. Fluid accumulates within the lens substance, causing it to swell. Later, the fluid resorbs and the lens shrinks. In order to ascertain how far towards the capsule the opacity has advanced, a light should be held near and at the side of the eye, and the shadow cast by the iris upon the opaque lens should be studied. If the shadow is wide, the opacity has not progressed far towards the capsule; if the shadow is narrow, the opacity lies near the capsule; while if there is no shadow at all, the cataract is complete, or "ripe," as it is expressed. There is a dull gray reflex from the pupil, and

no details of the fundus can be seen. The sectors of the lens can be distinguished. The opaque lens has shrunken within its capsule, and is easily separable from it. In case the lens is not removed at this stage, it disintegrates and shows signs of hypermaturity. The nucleus always escapes disintegration. If the lens breaks down into a milky fluid, in which the hard, brown nucleus sinks, the name "Morgagnian Cataract" is applied.

In children, in whom the nucleus is not hardened (so-called "soft" cataract), resorption of the lens may occur, and thus a spontaneous cure be effected.

**II. Capsular Cataract.**—This form of cataract is distinguished by its white color. It can be discovered by oblique illumination. The capsule itself never becomes opaque, but opaque substance is deposited upon its surface. *Anterior polar* cataract is situated at the anterior pole of the lens. It may be congenital or acquired. When congenital it lies beneath the capsule, and is caused by a proliferation and degeneration of its epithelium. A tissue resembling connective tissue forms at this point and tends to remain circumscribed. If anterior polar cataract is acquired, it develops only in childhood and is due to a perforating ulcer of the cornea. Upon obliteration of the anterior chamber, the lens becomes adherent to the wound. Proliferation of capsular epithelium occurs from irritation. After the anterior chamber is re-established, and the wound healed, the anterior polar cataract remains as an evidence of the contact of the lens with the cornea. This variety of cataract interferes very little with vision.

*Posterior polar* cataract is due to remnants of the hyaloid artery upon the posterior capsule of the lens. In fetal life this artery carries nourishment to the lens.

*Disturbances of vision* by cataract range from slight

annoyance to absolute blindness. Opacities situated within the pupillary area cast shadows upon the retina and are subjectively (entopically) perceived by the patient. The presence of opacity in the lens produces irregular lenticular astigmatism. Diffuse opacity causes marked failure of vision. If the opaque portion is peripheral and covered by the pupil, vision is not impaired. Progressive cataract causes gradual loss of sight. The ability to distinguish objects (qualitative vision) is finally lost, but the ability to perceive the presence and absence of light (quantitative vision) is retained in case the other structures of the eye are not diseased. A slight swelling of the lens renders an eye myopic. Patients who have been in the habit of wearing convex glasses for near use sometimes find that they can read or sew comfortably without their glasses. The "second sight" which they believe they have received is in reality due to a pathological process in the lens.

*Treatment.*—Before the true nature of cataract was known, its "cure" was accomplished by depression of the opaque lens into the vitreous. The opacity was believed to be in front of the lens.

Certain varieties of cataract are not subject to treatment, as, for instance, anterior and posterior polar cataracts. Operation should be performed for zonular cataract only when sight is decidedly impaired, and then choice should be made between iridectomy and radical removal. If the periphery is broad and clear, iridectomy is to be preferred. If removal of the lens is necessary, discission should be employed in cases of young persons and extraction in cases of adults. (For description of these operations, see Chapter xii.)

A progressive cataract should be allowed to mature, or in certain cases its maturity should be hastened by the

operation of iridectomy, followed by massage of the lens or by discission (see Chapter xii). The hypermature cataract offers obstacles to successful operation. Degenerative changes may render it friable or of even fluid consistency. A capsular cataract may develop in addition to the lenticular, and in this case the lens is no longer easily separable from its capsule, as in the mature cataract. In case the suspensory ligament atrophies, dislocation of the lens may complicate the operation of extraction. "Secondary cataract" is caused by opacity of lens substance which has not been extracted at the time of operation, or by opacity of the capsule. It can be removed by operation (see Chapter xii).

Cataracts due to diabetes are not favorable for operation, inasmuch as the corneal wound does not heal well and inflammation of the eye is liable to follow. This form of cataract is the one kind which responds to medicinal treatment.

The use of a weak solution of atropin in cases of nuclear cataract increases vision by widening the pupil. If mature cataract is present in one eye and opacity is beginning in the other, operation upon the mature cataract is indicated. But if one eye only is affected, the patient suffers after removal of the lens from disturbances of vision due to the unequal refractive power of the eyes. Even correction by glasses does not overcome the difficulty. On the other hand, if the operation is not performed at the stage of maturity, and subsequent injury or disease of the other eye make it imperative to remove the cataract, dangers arise from its hypermaturity.

**Injuries and Anomalies of the Lens.**

1. *Foreign Bodies* are better borne by the lens than by any other tissue of the eye, although they cause the lens

to become opaque (traumatic cataract). A piece of iron in the lens causes a brown stain from the formation of an oxid.

2. *Luxation of the Lens* may be congenital or acquired, partial or complete. When acquired, it is due to traumatism or to a weakened condition of the suspensory ligament. In partial luxation the lens is dislodged from the fossa patellaris and lies in an oblique position. In complete luxation the lens is dislocated either forwards into the anterior chamber or backwards into the vitreous. Much disturbance of vision is produced by any degree of dislocation of the lens. An iris which has lost the support of the lens is tremulous upon movement of the eye. The results of luxation are serious. The presence of the lens in the anterior chamber may cause keratitis and iridocyclitis, or it may be followed by glaucoma because of interference with the outflow of intraocular fluid. The lens should be extracted without delay. Dislocation of the lens into the vitreous is less serious, and often its presence there is tolerated for an indefinite period. The disturbance of vision caused by partial luxation or by the presence of the lens in the vitreous may be corrected by glasses. Extraction of the lens from the vitreous is difficult, and in case the eye becomes habitually inflamed and painful, enucleation should be performed for the sake of relieving pain and preventing sympathetic ophthalmia.

3. *Absence of the Lens* (aphakia) is sometimes congenital.

4. *Coloboma* may occur in the lens as a congenital defect; it is usually accompanied by corresponding coloboma of the iris or of the choroid or of both.

## II. THE ORBIT.

The orbit is pyramidal in shape. At the apex is the optic foramen, which opens into the middle fossa of the skull. Through this foramen pass the optic nerve and the

ophthalmic artery. The supra-orbital fissure transmits the nerves for the ocular muscles and the first branch of the trigeminus. Through the inferior-orbital fissure pass the branches of the second division of the trigeminus, the largest of which is the infra-orbital nerve. By means of this fissure the orbit and the temporal fossa are in communication. At the upper inner margin of the orbit is the supra-orbital notch, in which runs the supra-orbital nerve and artery. About four millimeters from the lower nasal margin is the opening of the infra-orbital canal, through which pass the nerve and artery of the same name. The nasal walls of the orbits are very thin and lie nearly parallel to each other. The temporal walls are much thicker and diverge from each other. The anterior margin of the orbit is rounded and thickened, and serves as a defense to the eye. The eye is more exposed to injury upon its temporal than upon its nasal side, for the nose is a protection.

Orbital fat and cellular tissue support the muscles, nerves, vessels, and the globe itself, while the fibrous capsule of Tenon surrounds the eyeball to the limit of the conjunctiva and serves as a socket.

**Periostitis** is an inflammation of the periosteum of the orbit.

*Etiology.*—The disease is most often due to injury. Blows or falls are liable to affect the margin, and therefore periostitis of this part of the orbit is more frequently observed than that of deeper and more hidden parts.

Syphilis and tuberculosis are conspicuous causes of periostitis, but usually the disease develops in consequence of injury as an exciting cause.

*Course* and *Prognosis.*—In favorable cases, complete resorption of exudate occurs without suppuration, but often the inflammation leads to the formation of abscess and to

caries. Extension of suppuration to the brain is especially to be dreaded in cases of periostitis involving the roof of the orbit. The course of the disease is usually very protracted. If caries occurs, a sinus forms which may not heal for years.

*Symptoms.*—

A. Subjective.

If the disease is limited to the anterior margin of the orbit, pain and sensitiveness to touch are felt at the site of the swelling. If suppuration occurs, the pain is increased and symptoms of general disorder become manifest. In case of involvement of the brain, symptoms of meningitis occur.

B. Objective.

Diagnosis can easily be made if the inflammation is near the margin of the orbit. The skin over the surface of the swelling becomes red and sensitive. If the exudate does not resorb without suppuration, abscess forms. After evacuation of the pus, a sinus remains and the diseased bone at its end can be felt with a sound. Discharge of pus continues until all the fragments of diseased bone are extruded, then the sinus heals, and a depressed, cone-shaped cicatrix remains. Prolonged periostitis may produce ectropion.

If the disease attacks a part of the orbit which is hidden from view and from touch, the diagnosis is difficult. If pus forms, it does not easily find an exit. Unless evacuated by operation, it finds its way at last either to the skin-surface of the anterior part of the eye or to the cranial cavity. There is edema of the lids, and marked inflammation of the conjunctiva, with chemosis; protrusion of the eye (exophthalmus) occurs as a result of swelling behind the eyeball. In consequence of this condition, the cornea

is not well protected and suffers more or less, in accordance with the degree of protrusion and the course of the disease.

*Treatment* should be both constitutional and local. Syphilitic cases respond quickly to appropriate medicines. Locally, moist, warm compresses promote resorption of exudate, and in case pus forms they hasten development of the abscess. Pus should be evacuated as soon as possible. If caries and a sinus occur, the treatment should be the same as that employed in general surgery.

In case the abscess is deeply situated within the orbit, its location should be determined if possible, then a free and deep incision made. The tissues are relieved of exudate, even if no pus is obtained.

**Cellulitis** (retrobulbar phlegmon) is an inflammation of the cellular tissue of the orbit.

*Etiology.*—(a) Infecting injuries, either with or without the introduction of a foreign body. In this division are included operations not aseptically performed. (b) Extension of inflammation or suppuration from adjacent tissues (as the skin or the bones of the orbit), or by metastasis, as in pyemia.

*Course* and *Symptoms.*—Clinically the disease is not easily separable from periostitis of the back of the orbit. There is great pain, fever, and exophthalmus, with formation of pus.

*Treatment.*—If a foreign body has lodged in the orbit, it should be removed if possible. If a constitutional disease is the cause of the cellulitis, appropriate medicines should be given. The local symptoms are relieved by warm, moist compresses, and if much exudate is present a pressure bandage is applied. Incision should be made as early as possible for the sake of relieving the distention of the tissues as well as for the evacuation of pus.

**Tenonitis** (inflammation of the capsule of Tenon) occurs

in combination with inflammation of tissues adjacent to the capsule, and rarely as a primary disease.

**Exophthalmic Goiter** (*Basedow's disease; Graves' disease*).

In this affection, protrusion of the eyeballs is a conspicuous symptom. When the eyes look downwards, the upper lids fail to cover the cornea and leave a line of sclera visible. This is Von Graefe's sign and is thought to be due to affection of the sympathetic nerve which supplies the superior palpebral muscle.

The symptoms which co-exist with exophthalmus are swelling of the thyroid gland and rapid beating of the heart (tachycardia). As a rule there is no organic lesion beyond enlargement of the left heart. Exophthalmus is the latest of the three cardinal symptoms of the disease to appear. In Basedow's disease the eyes suffer in proportion to the amount of exophthalmus which develops. Because of insufficient protection, the cornea becomes dry and keratitis is induced. Eversion of the lids may occur as a result of the pressure exerted upon them by the eyeball. Vision is affected in proportion to the involvement of the cornea. The movements of the eye are more or less restricted. Disease of the optic nerve may result from the tension to which it is subjected.

*Treatment* should be general and local. The cornea should be protected by every possible means, especially at night. This may be accomplished by a bandage, or the palpebral fissure may be narrowed by operation if necessary.

**Injuries of the Orbit.**

All varieties and gradations of injury of the orbit are observed. The margin may be injured by a blow or a fall, without implicating the eyeball, but as a rule injury of the

orbit implies injury also of its contents. Foreign bodies in the orbit should be removed if possible. Wounds should be dressed antiseptically, and the eye should be carefully watched for signs of suppuration. A dislocated eyeball may be replaced and remain serviceable, but in such severe injuries enucleation is usually indicated.

**Tumors of the Orbit.**

Dermoid cysts are the variety of tumor most frequently found in the orbit. Because of their position, which is usually at the upper, inner margin of the orbit, they can be removed; but care should be taken to dissect out the entire sac, for a part of it left in the wound causes recurrence of the tumor.

Sarcomata and carcinomata occur in the orbit, the former being the more usual. Early removal is recommended. Under favorable circumstances and when the tumor is small, removal may be accomplished without injury to the eye itself; but usually enucleation is necessary.

## CHAPTER XII.

### BRIEF DESCRIPTIONS OF IMPORTANT OPERATIONS.

#### I. UPON THE CONJUNCTIVA, LIDS, AND LACRYMAL APPARATUS.

**Operation for Chalazion.**

The lid may be turned and secured by Desmarre's forceps, but usually one can operate quite as easily while holding the everted lid with the finger. A depressed, discolored spot in the conjunctiva marks the point where the incision should be made. The cut should run in the same direction as the gland. A dull curette is used to remove the contents of the chalazion and to irritate the membrane lining the sac, so as to promote its absorption. The interior of the cavity is then touched with the copper or the silver stick.

**Operation for Trachoma** (*"Rolling"*).

Each lid is everted in turn, and with Knapp's rolling forceps the contents of the trachoma granules are pressed out. Care should be taken to destroy all the bodies in the conjunctiva, especially those which lie in the retrotarsal folds.

**Operation for Symblepharon.**

The adhesion is divided with scissors, after which small pledgets dipped in oil are kept between the lid and the eyeball, until cicatrization of each raw surface has occurred. In cases of broad adhesion, it will be necessary by skin grafting, or by a conjunctival flap, to cover the raw surface left on the eyeball.

**Canthoplasty.**

This is an operation done for the sake of widening the

palpebral fissure. It may serve as a means of temporary relief, as in edema of the lids, or as a permanent cure, as in blepharophimosis or in blepharospasm. The lids are separated widely, and the blunt point of a pair of scissors is introduced under the external commissure. A single horizontal cut is then made. If the canthoplasty is to be but a temporary measure, no stitches are taken; otherwise, the conjunctival and skin surfaces are united.

**Tarsorrhaphy.**

This operation has for its object the narrowing of the palpebral fissure and is indicated in cases of imperfect closure of the lids, as in ectropion and exophthalmus. The following method is the one employed by Fuchs: An incision dividing the cilia surface of the lower lid is made up to a point decided upon as the limit of subsequent union of the lids. At this point a short downwards incision is made, dividing the skin surface. A flap is thus made. An incision similar to the first and about 3 mm. deep is now made in the upper lid. The cilia of this region are "ablated" by another incision made through the skin of the lid about 3 mm. from its margin and of the same length as the one upon the cilia surface. The cilia with their follicles are removed and a raw surface is left upon the upper lid, and upon this the flap of the lower lid is made to rest. The adhesion of these surfaces is promoted by the use of a suture with a needle at each end. The needles are carried through the upper surface from underneath the lid, at points near its margin. A loop of thread is thus left on the conjunctival surface of the lid. Each needle is then passed through the flap of the lower lid, and the ends of the suture are tied. The advantage of this operation is that it makes union of the lids secure. Tarsorrhaphy performed at the outer can-

thus (lateral tarsorrhaphy) is much more frequently done than at the inner canthus (median tarsorrhaphy).

**Hotz's Operation for Entropion.**

An incision is made on the skin surface of the lid along the upper border of the tarsus. The lips of the wound are separated and the fibers of the orbicularis muscle are exposed and divided. Sutures are then passed through the upper lip, tarsus, and lower lip, and the wound is closed. By this means the skin of the lid may be drawn upwards (or downwards, in case of operation upon the lower lid) as far as desirable and stitched to the immovable tarsus. This operation is also done for trichiasis.

A simpler operation for entropion consists in the excision of a horizontal fold of skin near the margin of the lid and stitching together the edges of the wound. But, as the skin is likely to stretch, this method is not so sure in its effects as the Hotz operation.

**Operation for Epicanthus.**

A vertical fold of skin upon the dorsal part of the nose is excised, and the edges of the wound are united by stitches; or the fold of skin which constitutes the epicanthus may be excised.

**Dilatation of the Lacrymal Duct.**

The point of the sound is entered at the punctum and is pushed along in a horizontal direction until it touches the lacrymal bone, then it is turned in a vertical direction and slowly pushed downwards until it reaches the floor of the nose. A small sound should be introduced first, afterwards larger ones.

**Slitting the Canaliculus.**

After dilatation of the canaliculus by a sound, Weber's knife, with its cutting edge turned upwards, is introduced

at the punctum, and carried horizontally along until it reaches the lacrymal bone. The knife is then quickly raised to a vertical position and the canaliculus laid open.

**Extirpation of the Sac. Obliteration.**

The lids are drawn outwards by the finger placed at the external canthus, so as to put the internal palpebral ligament upon the stretch. The point of a sharp knife, held nearly vertical, is introduced underneath and at the center of the ligament. The skin and the anterior wall of the sac are then incised, and the mucous membrane of the sac is exposed. Extirpation is performed by dissecting out the mucous membrane, or by scraping it away with a sharp curette. Obliteration is accomplished by the introduction of a caustic into the sac or by electricity. After extirpation the external wound is closed by sutures, but after obliteration the wound should heal by granulation.

II. UPON THE CORNEA.

**Ablation of Pterygium** (*Arlt's method*).

The pterygium is grasped at the "neck" and is carefully dissected away from the cornea. The corneal portion, or "head," of the pterygium having been separated from its attachment, two short converging incisions are made in the conjunctiva, starting from the limbus and meeting in the body of the pterygium. The head, the neck, and that portion of the body of the pterygium which is included between the two incisions are then removed, and the edges of the conjunctival wound are united by sutures. An opacity of the cornea remains. In certain cases the head of the pterygium is dissected from the cornea and then stitched to some portion of the conjunctiva. This is called "transplantation," and is performed chiefly in cases of large

pterygia, as it does not necessitate the removal of conjunctival tissue.

**Paracentesis.**

This operation is performed for the purpose of emptying the anterior chamber of aqueous. It is best done with a slender knife; the Von Graefe is usually preferred. The point of the knife is introduced perpendicularly at the lower outer margin of the cornea, and after its entrance into the anterior chamber the knife is turned so as to lie in a horizontal position. The point is then carried in until a corneal wound about 2 mm. long is produced. The knife is then slowly withdrawn. The anterior chamber can be rapidly emptied by depressing the lower lip of the wound, but it is best to let the aqueous escape slowly and intermittently.

**Saemisch's Operation.**

The Saemisch incision of the cornea is done for the relief of abscess. The Von Graefe knife is introduced, cutting, edge forwards, into healthy corneal tissue near the outer margin of the abscess. The knife is carried into the anterior chamber, beneath the abscess, and the counter-puncture is made in healthy corneal tissue near the inner margin of the abscess. The abscess is then bisected by an incision directed forwards. The hypopyon is removed with a scoop or by irrigation of the anterior chamber. The wound should be kept open until it becomes healthy.

### III. UPON THE OCULAR MUSCLES.

**Tenotomy.**

Division of a tendon of an ocular muscle is best done under cocain, so that the result can be seen at once. The eye should be turned in a direction away from the muscle to be cut, and the lids are kept open by an eye speculum. A fold of conjunctiva lying over the muscle, and about four

millimeters from the margin of the cornea, is caught with fixation forceps, and with scissors a short vertical incision is made. With blunt-pointed scissors the conjunctiva is freely separated from the underlying connective tissue. A strabismus hook is then passed underneath the tendon, and with blunt scissors the tendon is divided close to the sclera. If any fibers remain undivided, they are caught up by the strabismus hook and are severed by the scissors. No suture in the conjunctiva is necessary, although a stitch is said to prevent retraction of the caruncle in cases of operation upon the internus. During the process of healing, the divided tendon becomes attached to the eyeball at a point behind that of its former insertion.

**Advancement.**

By this operation the insertion of a muscle is carried forwards. It is performed upon the antagonist of the stronger muscle and in connection with tenotomy of the latter. The conjunctiva lying over the muscle is divided as in tenotomy, and the tendon is caught up by the strabismus hook. A suture is now introduced near the upper margin of the tendon, from behind forwards, a few millimeters from the insertion of the muscle. Another suture is similarly introduced at the lower border of the tendon. The tendon is then divided near the sclera, as in tenotomy. The needle of the upper suture is then carried beneath the conjunctiva to a point near the upper margin of the cornea, where it is brought out. Similarly, the needle of the lower suture is made to emerge at a point near the lower margin of the cornea. The ends of the upper suture are then tied together; also those of the lower suture. The tighter the threads are drawn, the greater the advancement of the tendon. A slight over-correction is necessary, as the effects of the operation decrease during healing.

IV. UPON THE IRIS AND SCLERA.

**Iridectomy.**

A knife held horizontal, and with the cutting edge up, is introduced at the outer margin of the cornea. The point of introduction must be chosen with reference to the desired size of the section. If a large lens is to be extracted after the iridectomy, a correspondingly large wound is necessary. The knife is carried quickly across the anterior chamber in front of the iris, and is brought out at a point opposite that of entrance. The section is then completed by carrying the knife to the upper limit of the cornea. Iris forceps with tips together are then introduced into the anterior chamber. The tips are separated at a point opposite the pupillary margin of the iris and are made to grasp the iris and draw it out of the wound. With a pair of scissors a portion of the iris is then excised. With a spatula the angles of the wound are to be freed from iris tissue that may be caught in them. When this operation is done for glaucoma, the first section should lie in the sclera, and the excision of the iris should include its ciliary margin.

Iridectomy may be performed upon any part of the iris, according to the effect desired. In case of occluded pupil, or of central opacity of the cornea, an artificial pupil may be made opposite clear corneal tissue.

**Iridotomy.**

This operation consists in an incision of the iris without removal of any portion of it. It is performed only in lensless (aphakic) eyes, for incision of the iris could but injure the lens at the same time. It is adapted to cases of cataract extraction in which the development of a subsequent iridocyclitis has led to the formation of a membranous diaphragm which closes the pupil. The operation may be done

with a Von Graefe knife or with scissors-forceps. If the knife is used, an incision in the cornea is made, then the diaphragm is divided in a direction at right angles to that of its greatest tension. A gaping opening is thus made. In case of very tough, thick membrane, it is better to use scissors-forceps, so as to avoid dragging upon the iris. When the forceps are to be used, an incision is first made with a knife at the margin of the cornea. The forceps are then introduced closed. At a point opposite the diaphragm the forceps are opened and the posterior sharp edge thrust through it. The forceps are then closed and withdrawn.

**Sclerotomy.**

This operation is performed either at the anterior or at the posterior part of the sclera. When done at the anterior portion, the knife (preferably the Von Graefe) is held horizontal and is introduced into the sclera at a point about one millimeter from the corneal margin. It is then carried across the anterior chamber, in front of the iris, and is brought out at a corresponding point on the other side of the cornea. The knife is then carried upwards with a slight sawing movement, until an incision about 3 mm. long is made on each side of the cornea. The knife is then slowly withdrawn. In order to keep the iris away from the wound, a myotic should be instilled both before and after the operation. Sclerotomy is performed in cases of glaucoma, but is less satisfactory than iridectomy.

When performed at the more posterior part of the sclera, an incision is made which runs from behind forward. In order that the ciliary body may not be injured, the incision should not extend beyond a point about 6 mm. from the limbus of the cornea. When done for detachment of the retina, the situation of the detachment should be carefully

determined and the incision made accordingly. The subretinal fluid escapes and forms a bleb under the conjunctiva. As soon as the fluid has ceased to flow, the knife should be withdrawn. Posterior sclerotomy is also done in cases of glaucoma in which the anterior chamber is obliterated and iridectomy is impossible. Tension is lowered by the escape of vitreous, making a subsequent iridectomy easier of accomplishment.

### V. UPON THE LENS.

**Discission.**

As a preliminary to this operation, the pupil should be dilated by atropin. The discission needle is introduced into the anterior chamber at a point situated in the lower outer quadrant of the cornea, and is then carried forwards to the anterior capsule of the lens. Two or more light, sweeping incisions are made in the anterior capsule, and then the needle is quickly withdrawn, so as to lose as little aqueous as possible. The capsule having been divided, the lens imbibes aqueous humor, swells, and undergoes absorption. The lens is absorbed usually in the course of a few months, but in the meantime the operation must be repeated a variable number of times. The operation is performed for the removal of soft cataract and secondary cataract, and also to hasten the maturity of cataract.

**Extraction.**

In this operation the initial section is the same as that for iridectomy, and in most cases iridectomy is one of the steps of cataract extraction. The anterior capsule of the lens is opened either by the point of the knife used for the section or by a cystitome. Next, a spatula is placed against the lower portion of the cornea and gentle pressure backwards and upwards is made. This pressure must be

even and constant until the longest diameter of the lens has passed through the wound. Gentle stroking with the spatula removes any portions of the lens which may linger in the anterior chamber. If the iris protrudes, it is carefully replaced in the anterior chamber, and finally the lips of the wound are approximated. Instillation of eserin after the operation may prevent prolapse of the iris into the wound.

### VI. ENUCLEATION OF THE EYEBALL.

The lids are kept apart by an eye speculum. The eye is washed with a one per cent. solution of cyanid of potassium, care being taken to protect the other eye. The use of the cyanid is followed by that of boracic acid. The conjunctiva is then grasped with fixation forceps and is divided all around the cornea with a pair of scissors having one blunt and one sharp point. The conjunctiva is then separated from the underlying connective tissue. The tendons of the muscles are grasped one by one and severed at their insertions. Finally, blunt-pointed scissors are introduced into the orbit behind the eye, and the optic nerve is divided. After arrest of bleeding, a continuous suture should unite the raw edges of the conjunctiva. If the operation is performed antiseptically, healing takes place by first intention, and about fourteen days later the orbit is ready to receive a temporary artificial eye.

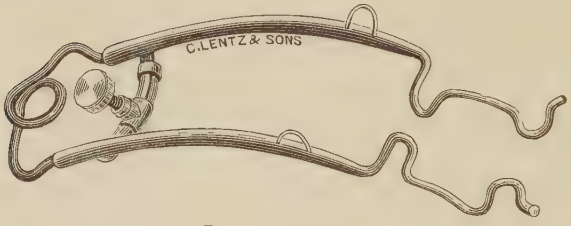



FIG. 17.—Speculum.


FIG. 18.—Fixation Forceps.


FIG. 19.—Strabismus Hook.

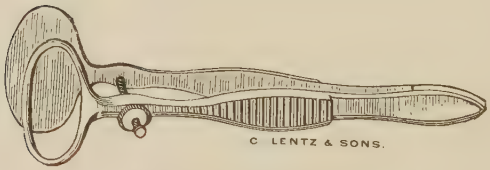



FIG. 20.—Desmarre's Forceps.

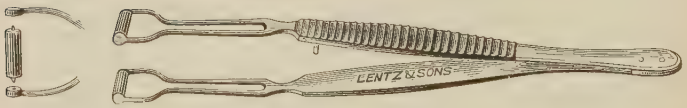



FIG 21.—Knapp's Roller Forceps.


FIG. 22.—Iris Forceps, curved.

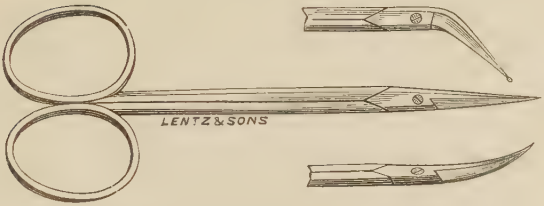



FIG. 23.—Iris Scissors, straight, curved, angular.


FIG. 24.—Spud for removing foreign bodies.


FIG. 25.—Von Graefe's Cataract Knife.


FIG. 26.—Beer's Cataract Knife.


FIG. 27.—Weber's Straight Canalicula Knife.


FIG. 28.—Cystitome.

FIG. 29.—Beer's Straight Cataract Needle.


FIG. 30.—Daviel's Scoop.


FIG. 31.—Tortoise Shell Spatula.


FIG. 32.—Shell or Rubber Lens Scoop

# GLOSSARY OF DERIVATIONS.

**Amaurosis**, fr. Gr. *ἀμαυρόω*, to darken. **Am. ex anopsia**, fr. Gr. *ἐξ*, from, *ἀ* privative (negative), and *ὤψ*, sight.
**Amblyopia**, fr. Gr. *ἀμβλύς*, blunted, and *ὤψ*, sight.
**Ametropia**, fr. Gr. *ἀ* privative (negative), *μέτρον*, measure, and *ὤψ*, eye.
**Aniridia**, fr. Gr. *ἀν* privative (negative), and *ἶρις*, rainbow.
**Aphakia**, fr. Gr. *ἀ* privative (negative), and *φακός*, lentil (see *lens*).
**Argyria**, fr. Gr. *ἀργυρος*, silver.
**Asthenopia**, fr. Gr. *ἀ* privative (negative), *σθένος*, strength, and *ὤψ*, sight.
**Astigmatism**, fr. Gr. *ἀ* privative (negative), and *στίγμα*, point.

**Blennorrhea**, fr. Gr. *βλέννος*, mucus, and *ῥοία*, a flow.
**Blepharitis**, fr. Gr. *βλέφαρον*, lid, and *itis*, "inflammation of."
**Blepharophimosis**, fr. Gr. *βλέφαρον*, lid, and *φιμώσις*, a shutting up of an orifice.

**Canthus**, fr. Gr. *κανθός*, the corner of the eye.
**Canthoplasty**, fr. Gr. *κανθός* (see *canthus*) and *πλαστός*, verbal adj. of *πλάσσειν*, to form.
**Caruncle**, diminutive form of Lat. *caro*, flesh.
**Cataract**, fr. Gr. *καταρράκτης*, waterfall.
**Chalazion**, diminutive of Gr. *χάλαζα*, stye.
**Chemosis**, fr. Gr. *χήμη*, a yawning, gaping.
**Choroid**, fr. Gr. *χορίον*, membrane, and *εἶδος*, like.
**Cilium**, fr. Lat. *cilium*, a cover, an eyelid.
**Collyrium**, fr. Gr. *κολλύριον*, an eye-salve.
**Coloboma**, fr. Gr. *κολοβόω*, to mutilate.
**Conjunctiva**, fr. Lat. *con*, together, and *jungo*, to join.
**Corectopia**, fr. Gr. *κόρη*, pupil, and *ἔκτοπος*, out of place.
**Cornea**, fr. Lat. *corneus*, horny.
**Cyclitis**, fr. Gr. *κύκλος*, circle, circular body, and *itis*, "inflammation of."
**Cystitome**, fr. Gr. *κύστις* (Lat. *cystis*), cyst (referring to capsule of lens), and *τομός*, cutting.

**Dacryocystitis**, fr. Gr. *δάκρυον*, tear, *κύστις*, sac, and *itis*, "inflammation of."
**Diopter**, fr. Gr. *διόπτρα* (fr. *διά*, through, and *ὄπτομαι*, obsol. pres. of *ορᾶω*, to see), a leveling instrument.
**Diplopia**, fr. Gr. *διπλόος*, double, and *ὄπτομαι*, obsol. pres. of *ορᾶω*, to see.
**Discission**, fr. Lat. *discindere*, to cut apart.
**Disk**, fr. Gr. *δίσκος*, a quoit.
**Distichiasis**, fr. Gr. *δίστιχος*, having two rows.

**Ecchymosis**, fr. Gr. *ἐκ*, out, and *χυμός*, fluid.

**Ectasia**, fr. Gr. ἐκ, out, and τείνειν, to stretch.
**Ectropion**, fr. Gr. ἐκ, out, and τρέπειν, to turn.
**Emmetropia**, fr. Gr. ἐν, in, μέτρον, measure, and ὤψ, eye.
**Entropion**, fr. Gr. ἐν, in, and τρέπειν, to turn.
**Epicanthus**, fr. Gr. ἐπί, upon, and κανθός, corner of the eye.
**Epilation**, fr. Lat. *e*, out, and *pilus*, hair.
**Epiphora**, fr. Gr. ἐπί, upon, and φέρειν, to bear.
**Episcleritis**, fr. Gr. ἐπί, upon, σκληρός, hard (whence *sclera*), and *itis*, "inflammation of."
**Esophoria**, fr. Gr. ἔσω, within, and φέρειν, to bear, to tend.
**Exophoria**, fr. Gr. ἐξ, out, and φέρειν, to bear, to tend.
**Exophthalmus**, fr. Gr. ἐξ, out, and ὀφθαλμός, eye.

**Fovea**, fr. Lat. *fovea*, a depression.

**Glaucoma**, fr. Gr. γλαυκός, bluish-green. **Gl. fulminans**, fr. Lat. *fulminare*, to lighten and thunder.

**Hemeralopia**, fr. Gr. ἡμέρα, day, and ὤψ, sight.
**Hemiopia**, fr. Gr. prefix ἡμι-, half, and ὤψ, eye.
**Heterochromia**, fr. Gr. ἕτερος, different, and κρῶμα, color.
**Heterophoria**, fr. Gr. ἕτερος, different, and φέρειν, to bear, to tend.
**Homonymous**, fr. Gr. ὁμός, the same, and ὄνυμα, name.
**Hordeolum**, diminutive of Lat. *hordeum*, barley.
**Hyaloid**, fr. Gr. ὕαλος, glass, and εἶδος, like.
**Hyphema**, fr. Gr. ὑπό, below, and αἷμα, blood.
**Hyperphoria**, fr. Gr. ὑπέρ, above, and φέρειν, to bear, to tend.

**Iris**, fr. Gr. ἶρις (Lat. *iris*), rainbow.

**Keratitis**, fr. Gr. κέρας, horn (see *cornea*) and *itis*, "inflammation of."

**Lacrymal**, fr. Lat. *lacryma*, tear.
**Lagophthalmus**, fr. Gr. λαγώς, hare, and ὀφθαλμός, eye, owing to the supposition that during sleep the eyes of the hare are open.
**Lens**, fr. Lat. *lens*, a lentil.
**Leukoma**, fr. Gr. λευκός, white.

**Macula**, fr. Lat. *macula*, a spot.
**Medium** (pl. media), fr. Lat. *medius*, middle.
**Meniscus**, fr. Gr. μηνίσκος, a crescent (diminutive of μήνη, the moon).
**Metamorphopsia**, fr. Gr. μετά, among (denoting interchange), μορφή, form, and ὤψ, eye.
**Muscæ volitantes**, fr. Lat. *musca*, fly, and *volitare*, to fly to and fro.
**Mydriasis**, fr. Gr. μυδρίασις, enlargement of the pupil.
**Myopia**, fr. Gr. μύειν, to close, and ὤψ, the eye.
**Myosis**, fr. Gr. μύειν, to close.

**Nucleus**, diminutive of Lat. *nux*, nut.
**Nyctalopia**, fr. Gr. νύξ, night, and ὤψ, sight.
**Nystagmus**, fr. Gr. νυστάζειν, to nod, to nap.

**Ora serrata**, fr. Lat. *os*, mouth (pl. ora), and *serra*, saw.
**Ophthalmology**, fr. Gr. ὀφθαλμός, eye, and λόγος, discourse.
**Ophthalmometer**, fr. Gr. ὀφθαλμός, eye, and μέτρον, measure.
**Ophthalmoplegia**, fr. Gr. ὀφθαλμός, eye, and πληγή, stroke.

**Ophthalmoscope**, fr. Gr. *ὀφθαλμός*, eye, and *σκοπεῖν*, to examine.
**Orthophoria**, fr. Gr. *ὀρθός*, straight, and *φέρειν*, to bear, totend.

**Pannus**, fr. Lat. *pannus*, cloth.
**Panophthalmitis**, fr. Gr. *πᾶς*, (*παν-*), all, *ὀφθαλμός*, eye, and *itis*, "inflammation of."
**Paracentesis**, fr. Gr. *παρά*, beside, and *κεντεῖν*, to pierce.
**Perimeter**, fr. Gr. *περί*, around, and *μέτρον*, measure.
**Phlyctenule**, fr. Gr. *φλύκταινα*, a blister, a vesicle.
**Photophobia**, fr. Gr. *φῶς*, light, and *φόβος*, fear.
**Photopsia**, fr. Gr. *φῶς*, light, and *ὤψις*, (fr. *ὤψ*), vision.
**Phthisis bulbi**, fr. Gr. *φθίσις*, a wasting away, decay, and *βολβός* (Lat. *bulbus*), a bulb.
**Pinguecula**, diminutive of Lat. *pinguis*, fat.
**Presbyopia**, fr. Gr. *πρέσβυς*, old, and *ὤψ*, eye.
**Pterygium**, fr. Gr. *πτερύγιον*, a little wing.
**Ptosis**, fr. Gr. *πτῶσις*, a fall.
**Pupil**, fr. Lat. *pupa*, a child, referring to the small reflected image of one's self in another's eye.

**Retina**, fr. Lat. *rete*, a net.

**Sclera**, fr. Gr. *σκληρός*, hard.
**Scotoma**, fr. Gr. *σκότωμα*, darkness.
**Skiascopy**, fr. Gr. *σκιά*, shadow, and *σκοπέω*, to examine.
**Staphyloma**, fr. Gr. *σταφυλή*, a bunch of grapes.
**Strabismus**, fr. Gr. *στραβισμός*, (fr. *στραβός*, crooked), a squinting.
**Symblepharon**, fr. Gr. *σύν*, together, and *βλέφαρον*, lid.
**Synechia**, fr. Gr. *σύν*, together, and *ἔχειν*, to hold.
**Synchisis**, fr. Gr. *σύν*, together, and *χέειν*, to pour. **Synch. scintillans**, fr. Lat. *scintillo*, to sparkle.

**Tarsorrhaphy**, fr. Gr. *ταρσός*, a broad, flat surface, and *ῥαφή*, a sewing together.
**Tarsus**, fr. Gr. *ταρσός*, a broad, flat surface.
**Trachoma**, fr. Gr. *τραχύς*, rough.
**Trichiasis**, fr. Gr. *θρίξ*, hair.

**Uvea**, fr. Lat. *uva*, grape. The choroid, the ciliary body and the iris, when dissected away from all other structures of the eye except the optic nerve, resemble a grape hanging from its stem.

**Vitreous**, fr. Lat. *vitrum*, glass.

**Xerosis**, fr. Gr. *ξηρός*, dry.

# INDEX.